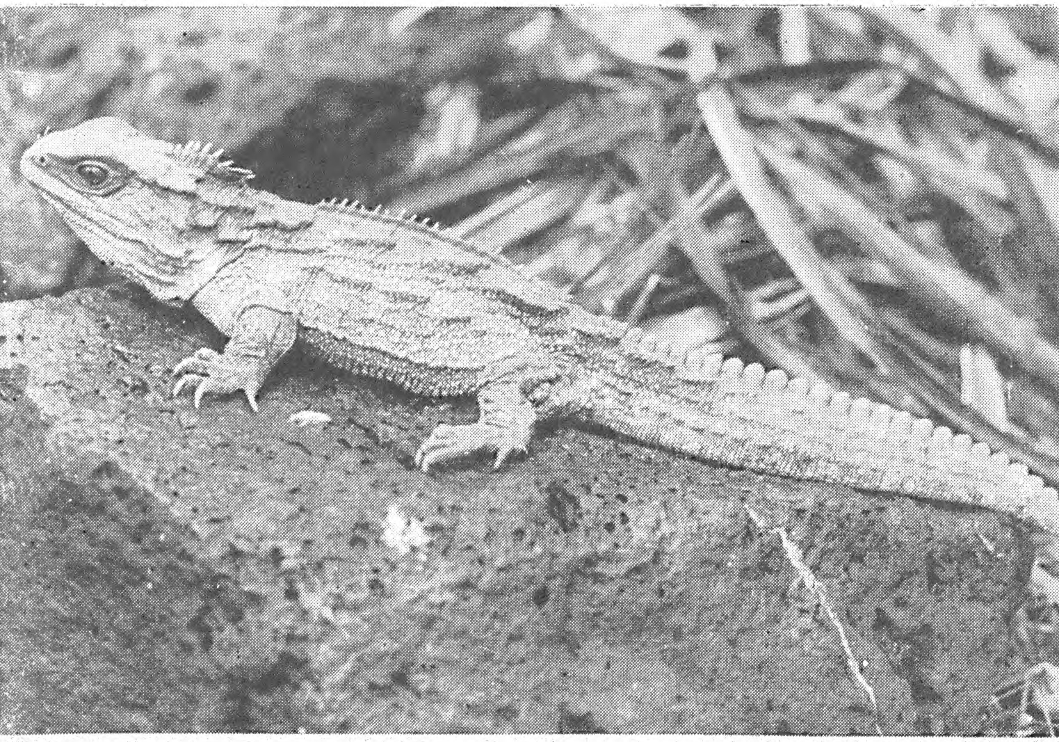
Rec. Price $5.00

HERPETOFAUNA

Vol. 14 No 1 & 2

August 1982
April 1983



THE TUATARA

Sphenodon punctatus (Gray) 1831.

The only surviving member of the reptilian order Rhynchocephalia.

Photo by P.A. West, Auckland Zoo.

Herpetoauna incorporates the *South Australian Herpetologist* and the *Bulletin of Herpetology* and is published twice yearly by the Australasian Affiliation of Herpetological Societies. The Affiliation started on an informal basis in 1974 and was formally established in 1977. It is the result of a formal agreement between member societies to participate in co-operative activities.

The Affiliation's objectives are to promote the scientific study of amphibians and reptiles and their conservation, to publish the journal *Herpetofauna*, to encourage liaison between member societies through Conventions, publications and field work, and to represent the interests of its member societies at the Regional level. It is not intended to be a separate society, nor is it to deplete member societies of their vital expertise and resources.

The five member societies are:—

AUSTRALIAN HERPETOLOGICAL SOCIETY

President: Ross Hengley Secretary: Jeff Banks
Correspondence to: P.O. Box R79, Royal Exchange, Sydney. NSW. 2000

NEW ZEALAND HERPETOLOGICAL SOCIETY

President: Brian Humberstone Secretary: A.J. Harwood.
Correspondence to: 66 Don Buck Rd., Massey 8 Auckland. N.Z.

SOUTH AUSTRALIAN HERPETOLOGY GROUP (INC.)

President: Brian Roberts
Correspondence to: S.A.H.G. c/- S.A. Museum, North Tce., Adelaide, SA. 5000

VICTORIAN HERPETOLOGICAL SOCIETY

President: Neil Street Secretary: Mark Beacham
Correspondence to: 16 Suspension St., Ardeer, VIC. 3022.

WESTERN HERPETOLOGY GROUP

President: Greg Johnston
Correspondence to: 16 McEwin St., Whyalla Playford, SA. 5600

Member Societies bulk subscribe to Herpetofauna on behalf of their members. Overseas and Australasian herpetologists who do not belong to one of the Affiliated Societies are invited to subscribe direct (a three year subscription is Aust $12 for addresses in Australasia and Aust. $18 elsewhere including postage — please forward cheques, drafts etc in Australian currency to the Editor. Overseas airmailed subscription is available at Aust. $30 for three years).

Conventions are held for Affiliation society members and visitors about every two years in a field location or hosted by a member society in its home city.

OFFICE BEARERS:

Convenor: Harry Ehmann, School of Biological Sciences,
Sydney Technical College, Broadway, N.S.W. 2007.

Editor: Gerry Swan,
P.O. Box R307, Royal Exchange, Sydney. 2000

Councillors: AHS — Kim Kennerson
NZHS — Peter West
SAHG — Chris Harvey
VHS — Brian Barnett
WHG — Greg Johnston

Herpetofauna 13(2) was posted to member societies and individual subscribers in April 1982.

HERPETOFAUNA

Vol. 14 No 1 1982

NEW ZEALAND FROGS

By Ben D. Bell

Zoology Department, Victoria University of Wellington, Wellington

A paper given to the Convention of the Australasian Affiliation of Herpetological Societies, Auckland, New Zealand on 24th October 1981.

General Introduction

We know much more about the New Zealand frog fauna today than we did when the New Zealand Herpetological Society was founded in 1968. Richard Sharell's book *The Tuatara, Lizards and Frogs of New Zealand* appeared in 1966 and it was doubtless an important catalyst in the growth of interest in New Zealand herpetology over the 1970's. The Society also played an important role, and the production of its newsletter did much to inform members about New Zealand's herpetofauna, including both the endemic and introduced frogs.

For example Schipper (1970) discussed the New Zealand frogs and included Barwick's colour plate first published in *Tuatara:* 8 (1961 - see Fig. 1); Bell (1971a,b, 1972) launched a national distribution survey of frogs and provided information on the identification and status of species then believed to be in New Zealand (following McCann 1961, Stephenson 1961 and Sharell 1966).

In October 1971 the Society adopted the title *Pepeke* for its newsletter; according to Schipper (1971) 'Pepeke' is a Maori name for the endemic frog *Leiopelma hochstetteri* (Robb (1980, p.19) lists other Maori names and notes that Dr P. Hohepa believes there were no pre-European words in the Maori language for frog). *Leiopelma hochstetteri* drawn for the first issue of *Pepeke* by Ann Bell, remains an emblem of the Society (see Fig. 2), which is appropriate since it links New Zealand herpetology with a uniquely New Zealand amphibian group of great interest and antiquity; (the Tuatara *Sphenodon punctatus* might well have been another candidate had the Biological Society of Victoria University of Wellington not already adopted it as title and emblem for its own journal!).

It is now exactly 10 years since that first *Pepeke* appeared, and since the New Zealand frog distribution survey was launched. We now have a more accurate knowledge of our existing frog fauna and some exciting new discoveries have been made about their relationships, breeding and distribution. Most of these developments are described in a review recently given at the 1980 New Zealand Herpetology Symposium held in Wellington (Bell 1982), while Robb (1980), in her book *New Zealand Amphibians and Reptiles,* updates the information on frogs given by McCann (1961), Stephenson (1961), Sharell (1966), Crook (1974), Bull and Whitaker (1975), and others.

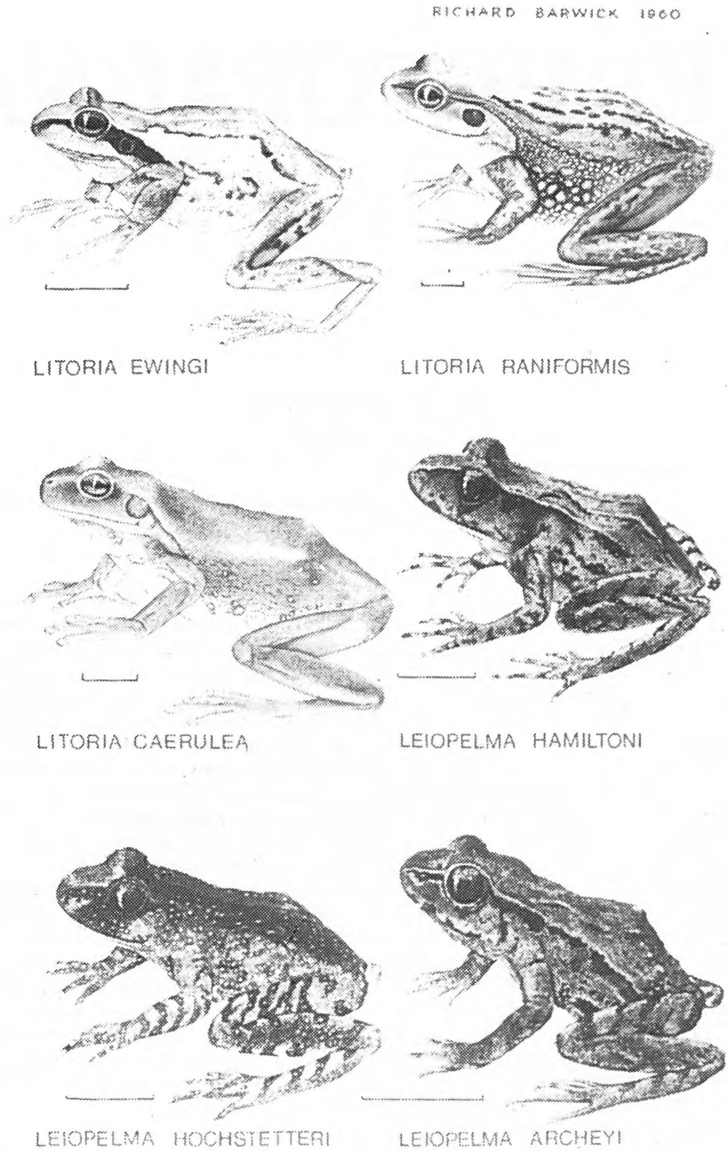


Figure 1 Photograph of the original of R.E. Barwick's colour plate of the New Zealand frogs published in *Tuatara* (1961), with current scientific names and scales of relative size (each representing 10 mm) added. *Litoria caerulea* has not apparently established in New Zealand, while *Litoria aurea* (*sensu* Courtice and Grigg 1975) is not illustrated (but see Fig. 8(a)).

In the present paper my approach will be to provide a description of the existing frog fauna of New Zealand, covering such aspects as identification, distribution, habitat, reproduction, development and systematics. The fauna now comprises six species of frogs: three endemic *Leiopelma* species *(L. archeyi, L. hamiltoni, L. hochstetteri)* and three introduced *Litoria* species from Australia *(L. aurea, L. ewingi, L. raniformis).* Three other Australian *Litoria* species *(L. adelaidensis, L. caerulea, L. gracilenta)* have also been reported from New Zealand but there is no evidence that they have successfully naturalised here *(Bell 1982).* The endemic and introduced species will now be considered in turn.

THE ENDEMIC LEIOPELMA SPECIES

Introduction

Like so many of the archaic biota, the endemic frogs have become rare and restricted in distribution since human settlement of New Zealand. They are protected by the N.Z. Wildlife Act 1953 so it is illegal for the individual to study or collect them without government approval. They are also listed in the Red Data Books of the I.U.C.N. and of New Zealand (Williams and Given 1981). Amongst anatomical features generally regarded as "primitive" are: the persistence of two small "tail-wagging" muscles in the adult; the retention of free ribs (not fused to the vertebrae) in the adults; the presence of amphicoelous vertebrae; and nine presacral vertebrae (usually eight in other frogs). The only other living frog having these anatomical features is the Tailed Frog, *Ascaphus truei* of the N.W. United States (Stephenson 1961; Bell 1982).

The endemic frogs (Fig. 1) are relatively small species, well camouflaged and secretive in habits, being largely nocturnal and occurring only in limited areas of cool, native forest or ridge-tops. They are therefore unlikely to catch the attention of the casual passer-by — in contrast to the more widespread introduced *Litoria* species that call loudly in the breeding season and may be seen in large numbers at breeding ponds or on roads at night. Nevertheless the endemic frogs have for many years caught the keen attention of biogeographers, systematists, anatomists and ecologists: they are of considerable scientific importance due to their great antiquity, their mode of life and their relict global distribution. Collectively herpetologists, especially those in New Zealand, therefore have an international responsibility to ensure the effective preservation of remaining populations. The present New Zealand legislation is to some extent inadequate since habitats are still being lost on the mainland (Bell 1981). However, with responsibility under the present Wildlife Act, the Wildlife Service has done much to foster their conservation, especially regarding *L. hamiltoni,* as the paper by D.G. Newman (this Convention) testifies (see also Newman 1977, 1982).

HOCHSTETTER'S FROG, LEIOPELMA HOCHSTETTERI

This was apparently the first species of endemic New Zealand frog to be reliably reported by Europeans and formally described in the scientific literature. Thomson (1853) reports a find by gold-diggers in the creeks behind Coromandel in November 1852:

> "In excavating the banks they displaced several large boulders of quartzy rock, underneath which was discovered the living frog. The gold-diggers, who voluntarily submit to the evils and miseries of such a gambling trade, and can rarely be excited by anything unless a great nugget, were so much astonished at the sight of a frog that one of them desisted from the seductive occupation he was at, and took the frog, and put it into a bottle . . ."

Subsequently, specimens collected from the Coromandel Ranges by Dr von Hochstetter, a naturalist travelling with the Austrian frigate *Novara,* were given to Dr Fitzinger, who described the species and named it *Leiopelma hochstetteri* (Fitzinger 1881).

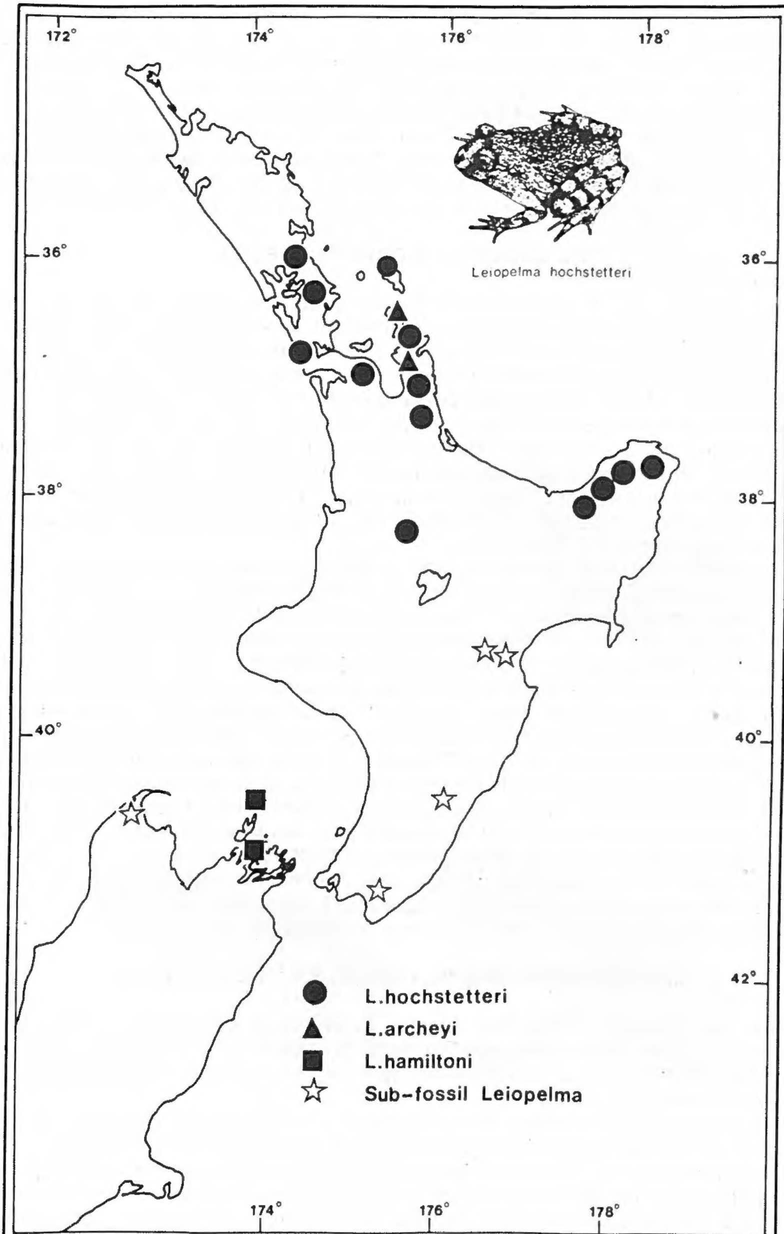


Figure 2 The distribution of *Leiopelma* in New Zealand as illustrated by Bull and Whitaker (1975), with the 1980 Great Barrier Island record of *L. hochstetteri* added. The frog illustrated is also the emblem of the N.Z. Herpetological Society drawn by Ann Bell.

Identification

Distinguished from *Litoria* species by absence of external eardrum (tympanum) and moreorless rounded pupil and from *Leiopelma archeyi* and *L. hamiltoni* by having distinct webbing on hind toes (extending about half their length) and by not having a distinct glandular parotoid ridge behind the eye (Fig. 1). *L. hochstetteri* is more robust in body-form than the other two *Leiopelma* species, with broader limbs and body but shorter snout and digits. Adult males have broader, more muscular, forelimbs than females, although adult females reach a greater snout-vent length than males (maxima 44 mm and 38 mm respectively).

Cryptically and variably coloured, ranging from dark, medium or light brown, through shades of orange or olive-brown to predominantly green. Typically, there is darker banding on the limbs and a lighter-coloured patch on the upper snout between and anterior to the eyes (see Fig. 1). Vocalisations limited to single chirping calls were heard during handling or when mating (Bell 1978a).

Distribution

This is the most widespread of the *Leiopelma* species, occurring in scattered localities from near Whangarei, south through the Warkworth, Auckland and Coromandel districts to the Rangitoto Ranges and East Cape (Fig. 2). It was found on Great Barrier Island in 1980 (Ogle 1980, Bell 1982) while a recent unconfirmed report S.W. of the Ureweras may refer to this species (D.G. Newman, pers. comm.). Although its known range has increased through new locality records over the last 10-15 years, it is nevertheless a species that has declined through habitat loss since European settlement. Some populations are still facing reduction or even local extinction, despite it being a protected species under the Wildlife Act 1953 (Bell 1981, 1982, Williams and Given 1981).

Habitat

L. hochstetteri occurs mostly in the vicinity of cool, shaded, rocky forest creeks and water seepages, occupying generally wet or muddy sites under the cover of rocks, logs or vegetation, although often emerging from cover at night, especially during wet or humid weather. Occupying a creek-bed habitat subject to periodic flash-flooding, *L. hochstetteri* inhabits a more turbulent environment than the other two *Leiopelma* species (but is not a particularly adept swimmer, although surviving immersion in water for at least 10 minutes (Turbott, 1942, Bell 1978a)). It is primarily a frog of creek banks and creek-beds, rather than of the creek waters — more a 'water-sider' than a truly aquatic species like, say, the rare and possibly archaic *Rheobatrachus silus* of Queensland which inhabits the *waters* of a rainforest creek (and somewhat resembles the African clawed frog *Xenopus*). Being concentrated in a relatively narrow habitat zone along sheltered forest creeks, *L. hochstetteri* is not only vulnerable to local disturbance, but to disturbances higher up the catchments in which it occurs. The species does not survive well in creeks subjected to heavy silting or extreme changes to water flow or quality as a result of human activities.

Reproduction and Development

L. hochstetteri breeds in cool, wet, secluded sites in muddy seepages alongside creeks under the cover of rocks, logs or vegetation. The broader, more muscular forelimbs of the male may facilitate his clasping of the female during amplexus, which is in the pelvic position (Bell 1978a). Strings of 10-12 large, yolky eggs are deposited; two such strings found at breeding sites may represent either one from each ovary, or perhaps two females being involved, and more studies are needed to clarify this (Turbott 1949, Stephenson 1955, Bell 1982). The pale whitish-yellow yolks (approx. 5-7 mm diameter) are enclosed in a clear capsule (12-16 mm diameter) comprising an outer coat, a middle gelatinous layer and an inner vitelline membrane.

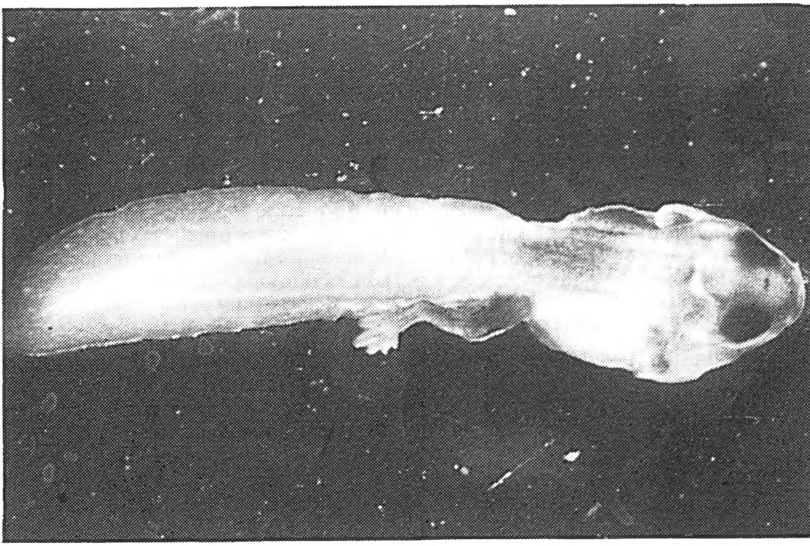


Figure 4 *Leiopelma hochstetteri* larva. Note pigmented eyes, branchial membrane over forelimbs, streamlined body with relatively small abdominal yolk stores, exposed hindlimbs and long muscular tail with well-developed fins. Total length 23 mm. Photo B.D. Bell.

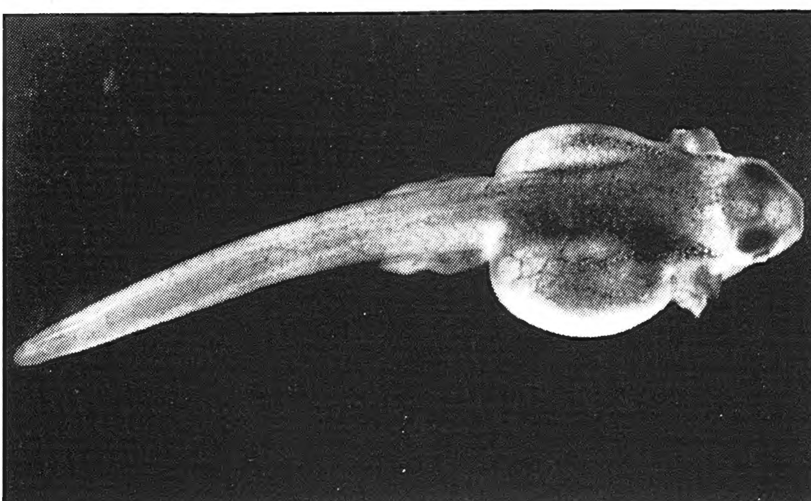


Figure 6 *Leiopelma hamiltoni* larva removed from egg capsule approx. 2 months after laying. Note pigmented eyes, glandular parotoid tracts, relatively small branchial membrane with forelimbs partially exposed, abdomen distended with yolk reserves, exposed hindlimbs and muscular tail with poorly developed fins. Total length 21 mm. Photo B.D. Bell.

As development proceeds pale grey embryos become evident on the dorsal surface of the egg, these later developing into whitish, tailed larvae (the well vascularised tail evidently facilitating intracapsular respiration). Prior to hatching capsule widths may reach 20 mm, and larvae recently seen hatching measured 17-18 mm (total length). In *L. hochstetteri* the larvae (Fig. 4) have well-developed tail-fins and the developing forelimbs are covered by the branchial (gular) membrane for much of their development (Stephenson 1955). This probably provides some protection (Bell 1978a) and also gives the body a more streamlined form, for the larvae are rather tadpole-like and capable of swimming in the rivulets of water in seepages; the more terrestrial larvae of the other two *Leiopelma* species (see Fig. 6) are less streamlined and less mobile (Bell 1982). *L. hochstetteri* larvae reach a length of 23-27 mm, and as development proceeds the forelimbs emerge free of the branchial membrane, which then recedes (Stephenson 1955); as yolk and tail are absorbed the larva finally develops into a tiny frog (9-10 mm snout-vent length).

These observations, based on larvae held in incubators at 15°C over 1980-81, indicate *L. hochstetteri* eggs hatch approximately 5 weeks after being laid and complete metamorphosis some 11 weeks after hatching (Bell, in prep.). Males were found close to egg clusters seen in Coromandel in November 1980, although it is uncertain whether *L. hochstetteri* broods the eggs as closely or for as long as in the other two *Leiopelma* species. Although amplexus was first observed in 1972, *L. hochstetteri* did not breed successfully in captivity until 1981: 5 metamorphosed frogs and 4 extracapsular larvae were found with adults on 4 January 1982.

Systematics

Although the three endemic frogs are congeneric species, the semi-aquatic *L. hochstetteri* differs from the other more terrestrial species in its development, adult anatomy, behaviour and ecology (Bell 1978a). The karyotype is 22 compared with 18 in *L. archeyi* and *L. hamiltoni* (Stephenson, Robinson and Stephenson 1974). Recent biochemical studies using electrophoresis (Bell and Harper unpubl., Daugherty, Bell, Adams and Maxson 1981) and microcomplement fixation (Daugherty, Maxson and Bell 1982) support this dichotomy within the genus and suggest *L. hochstetteri* diverged from the *L. archeyi/L. hamiltoni* lineage during the Miocene, some 14-15 million years ago. Moreover they suggest a distant relationship of *Leiopelma* with *Ascaphus truei* of North America, for the two genera immunologically "recognise" each other, but their divergence is estimated to have been 60-70 million years ago, in the late Cretaceous/early Tertiary (Daugherty, pers. comm.).

HAMILTON'S FROG, LEIOPELMA HAMILTONI

This frog was first discovered on Stephens Island in Cook Strait by Mr R.G. Smith in 1915 although it was formally described and named by McCulloch (1919) after Mr Harold Hamilton, then of the Dominion Museum, who followed up the initial report and sent McCulloch the type specimen (Crook, Atkinson and Bell 1971). In a letter received in 1977 from Mrs Emily Scott of Christchurch relating to these events, she wrote:

> "This frog was discovered by my brother, Richie Smith, in 1916*. We as children were sheltering from the wind — in the crater-like boulder strewn hollow on the summit of Stephens Island. My brother was shifting some rocks to make a seat, when he found this wee frog. We took it home and our father, . . . sent it to Mr Hamilton who . . . identified it as a previously unknown species and thanked our father for forwarding it to him. Mr Hamilton and a Mr O'Connor visited us at the Island several times, to study the frogs "habitat" . . ."

* Note after communicating with Mr R.G. Smith, Crook et. al. (1971) cite the discovery date as 1915, not 1916.

Identification

Distinguished from *Litoria* species by absence of external eardrum (tympanum) and by more or less rounded pupil, and from *L. hochstetteri* by having a distinct glandular parotoid ridge behind the eye and by lack of webbing between the hind toes (Fig. 1). Only differentiated from allopatric *L. archeyi* populations by greater adult size (snout-vent maxima for *L. hamiltoni* and *L. archeyi* are 49 mm and 37 mm respectively), and in never being conspicuously green in colour (except for some juveniles). *L. hamiltoni* is cryptically patterned in various shades of brown, the population on Stephens Island tending to be paler than that on Maud Island. Females tend to be larger than males (maximum snout-vent lengths 49 mm and 43 mm respectively), and may have ova visible through the ventral abdominal wall, but the forelimbs of *L. hamiltoni* are not sexually dimorphic as in *L. hochstetteri*. Vocalisations limited to simple chirping calls, often repeated (Bell 1978a, 1982).

Distribution

L. hamiltoni is one of the rarest frogs in the world, being known only from limited areas of habitat on Stephens and Maud Islands in Cook Strait (Fig. 2). Doubtless it was formerly more widespread in the region, and may still persist in a few other areas, but both localities have been free of small introduced mammalian predators such as rats, suggesting the species may be unable to coexist with them elsewhere. Extension of existing habitats and transfers to new areas are planned for the future while small colonies of both populations are now held in captivity (Bell 1978b, 1982. Newman 1977, 1982).

Habitat

On Stephens Island *L. hamiltoni* is now confined to a 600 + m² rock-pile at 275 m on the main ridge near the summit (Fig. 3b); on Maud Island it is confined to a 15ha remnant of coastal forest with logs, abundant stones, boulders and scree at 90-300 m (Fig. 3c). On both islands it was presumably more widespread before forest was cleared for agriculture, especially on Stephens Island where the 'frog bank' habitat (Figs. 3b and 5) is now revegetating and less exposed than in the 1940's when the species was thought possibly extinct (Crook et. al. 1971). Like *L. archeyi, L. hamiltoni* is a more terrestrial species than *L. hochstetteri* occurring under forest or on ridge tops, particularly under rocks and scree from which the frogs may emerge at night, especially when wet (Bell 1978a).

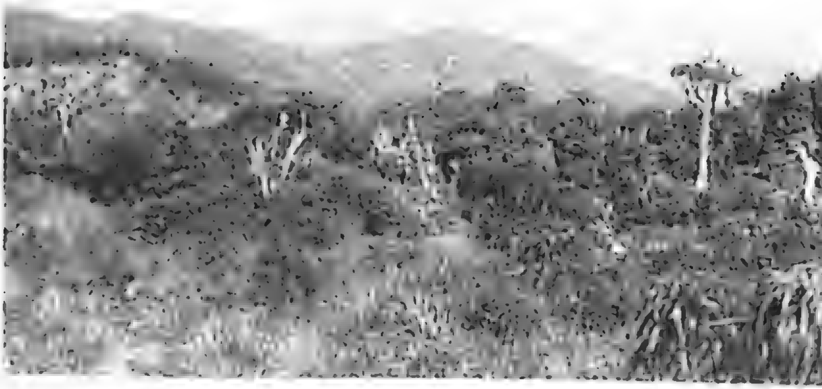
Although both Maud and Stephens Islands are reserves, and habitats there are being restored, the risk of chance or accidental introduction of predators remains. (Stoats appeared on Maud Island in 1982, apparently through self-introduction. Although the Wildlife Service is attempting to exterminate them, their possible impact on the frogs and other endemic fauna causes concern. *L. hamiltoni* may be more vulnerable to small mammal predation than the other two species and more study of behavioural and chemical defences of *Leiopelma* against predators is needed.)

Reproduction and Development

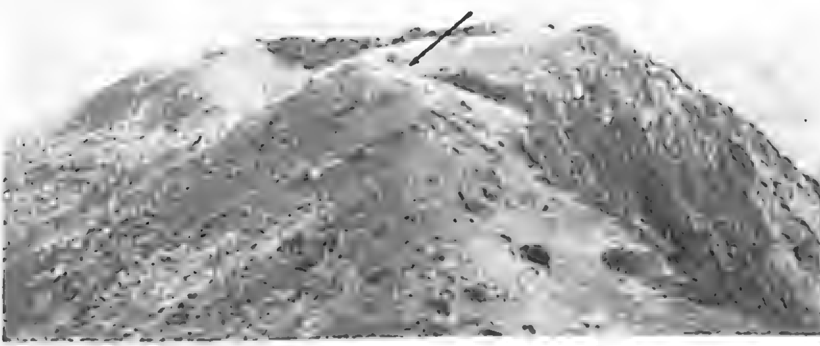
Despite recent searches on Maud Island (Bell 1978a) and in earlier years on Stephens Island, no eggs or larvae of *L. hamiltoni* have been found in either

Figure 3 Habitats of *Leiopelma* species. (a) Mixed forest/*Dracophyllum-Sphagnum* habitat of *L. archeyi* at 800m on Mount Moehau, Coromandel. While *L. archeyi* occurs at higher altitudes (►400m), *L. hochstetteri* is concentrated linearly along the seepages and creeks that drain the Coromandel ranges. Photo B.D. Bell, 1973. (b) Summit ridge of Stephens Island, Cook Strait, showing position of the 600 + m² rocky 'frog-bank' habitat of *L. hamiltoni* (arrowed). Photo B.D. Bell, 1974. (c) Slopes of Maud Island, Pelorous Sound, showing 15 ha. coastal forest habitat of *L. hamiltoni*. Photo B.D. Bell, 1974.

a



b



c

Figure 5 A party of zoologists searching through rocks on Stephens Island for *Leiopelma hamiltoni* in the 1950's. The species was thought possibly extinct there until its rediscovery by Dr W.H. Dawbin in 1950. The population of 100+ frogs now enjoys full protection in its 600+ m² rocky 'frogbank' habitat, which is left undisturbed under present N.Z. Wildlife Service management policy. Photo M.D. King.

habitat. However, its breeding and development have been documented from stocks of both island populations held in captivity over recent years (Bell 1977, 1978a, 1978b, 1981, 1982). These captive *L. hamiltoni* have laid eggs in enclosures in cool, moist terrestrial situations in shallow depressions under logs and stones; over 1976-80 Maud Island females laid 16 clusters of 7-19 eggs (mean 11.8), while over 1978-80 Stephens Island females laid 10 clusters of 5-9 eggs (mean 6.8). Compared with the limited sample of *L. hochstetteri* eggs examined, those of *L. hamiltoni* (and *L. archeyi*) tend to have deeper yellow yolks, and the embryos are whitish rather than pale grey. The egg capsules of *L. hamiltoni* tended to be slightly smaller than *L. hochstetteri* (initially 8-10 mm across, although with addition of moisture they tended to swell reaching 12-14 mm prior to hatching). The larva, described more fully by Bell (1978a, 1982) resembles *L. archeyi* but differs from *L. hochstetteri* in having only the bases of the forelimb covered by the branchial (gular) membrane and in having relatively narrow tail fins (Fig. 6). The larvae reach 21-24 mm in length, slightly larger than *L. archeyi* but slightly less than *L. hochstetteri* which has a somewhat longer tail. The newly metamorphosed frog is larger than the other two species (approx. 11 mm snout-vent length). The male *L. hamiltoni* exhibits brood-care, remaining close to the egg cluster, not only until hatching but until late stages of development when maturing larvae climb onto its limbs and back (Bell 1978a, unpubl.).

Systematics

Apart from its larger size and colour, *L. hamiltoni* closely resembles *L. archeyi* in external morphology (Fig. 1), as well as in its ecology, behaviour, development

and karyotype (Bell 1978a, Stephenson, Robinson and Stephenson 1972, 1974); Stephenson (1960, 1961) interpreted *L. archeyi* as a neotenic form of *L. hamiltoni*, the adult *L. archeyi* resembling the immature *L. hamiltoni* in the limited extent of skeletal ossification and in its body size. The two species therefore appear closely related, and may represent remnants of a formerly continuous population (Bell 1977).

Recent biochemical studies indicate the date of divergence between these species was in the Pliocene some 4-5 million years ago, when a sea straight across the southern North Island (Fleming 1975, Stevens 1980) was probably the barrier that separated them. Thus, despite their similarity, the divergence of these two species appears to be a relatively old event, and not one that occurred as a result of the more recent opening of Cook Strait (Fleming 1975, Stevens 1980). The distinctive *L. hochstetteri* diverged from the *L. archeyi/L. hamiltoni* lineage even earlier (estimated to be in the Miocene), attesting to the age of the extant species, which probably arose from former Gondwanaland stock (Savage 1973, Daugherty, Bell, Adams and Maxson 1981, Daugherty, Maxson and Bell 1982).

ARCHEY'S FROG, LEIOPELMA ARCHEYI

Although there are early records of small brown and green frogs high on the Coromandel ridges (McLaren 1898, Smith 1921, Archey 1922, Graham 1924) these frogs were not described as a distinct species until 1942 when E.G. Turbott, following an M.Sc. study in 1937, described and named *Leiopelma archeyi* after Sir Gilbert Archey who had provided the first accounts of the early development of the species and the genus (Archey 1922, 1935, Turbott 1937, 1942).

Identification

Distinguished from *Litoria* species by absence of external eardrum (tympanum) and by more or less rounded pupil. Although partially sympatric with *L. hochstetteri, L. archeyi* is small (snout-vent length up to 37 mm), has distinct glandular parotoid ridges behind the eye and lacks webbing between the hind toes (Fig. 1). It is smaller than the allopatric *L. hamiltoni* and many individuals are conspicuously green, or attractive combinations of various shades of brown and green. Indeed, the cryptic colour pattern of *L. archeyi* is extremely varied, ranging from rather demure brown specimens (like small *L. hamiltoni*) to beautiful patterns of green, brown and pink — gold and gem-stones notwithstanding, this small frog is surely the jewel of Coromandel! Females tend to be larger than males (maximum snout-vent lengths 37 mm and 31 mm respectively) and may have ova visible through the abdominal wall, but unlike *L. hochstetteri* males do not have thicker forelimbs. Although a smaller-sized population has been suggested for Mt. Moehau (Stephenson and Stephenson 1957, Stephenson 1961), more recent studies suggest size differences, if any, are not great (Bell 1978a). *L. archeyi* has only simple chirping calls, often repeated, given during handling and when breeding (Bell 1978a).

Distribution

L. archeyi is only known from the Coromandel Ranges, occurring on Mount Moehau, on the ridges behind Coromandel township and in the forested ranges further south (Fig. 1). It is therefore very local in distribution and while abundant in suitable localities must nevertheless be considered a rare frog on the basis of its limited range. One conservation priority is a thorough regional survey to determine its precise distribution and habitat range (Bell 1981): the southern limit of distribution, for example, is not known with certainty.

Habitat

Like *L. hamiltoni, L. archeyi* is a more terrestrial species than *L. hochstetteri* occurring under forest or on open mist-prone mountain ridges (Bell 1978a - see Fig. 3a). It is only known from higher altitudes (400-830 m) in Coromandel,

although rock-strewn forest at lower altitudes is also worth searching for this species (Bell 1978a). Turbott (1942) stressed the separate habitats of the sympatric *L. archeyi* and *L. hochstetteri*, but the two species were found together on the Tokatea ridge and Tapu summit (Stephenson and Thomas 1945, Stephenson and Stephenson 1957, Bell 1978a). However, in such areas of overlap *L. hochstetteri* is much less plentiful and tended to occupy wetter sites near seepages (Bell 1978a) Large-scale mining developments in the Coromandel Peninsula could be detrimental to populations of Archey's frog, as well as to local populations of *L. hochstetteri* (Bell 1981).

Reproduction and Development

Archey (1922, 1935) first described the early development of *L. archeyi*. Like *L. hamiltoni*, it breeds in cool, moist secluded sites under the cover of rocks, logs or vegetation under forest or on open mist-prone ridges (Archey 1922, Stephenson 1951, Stephenson and Stephenson 1957, Stephenson 1961 and Bell 1978a). Amplexus is of the pelvic type and a cluster of relatively few, large yolky eggs is laid in a small depression, very like *L. hamiltoni* (Bell 1977, 1978a). Indeed the pattern of development and larval morphology (see Fig. 7) is very similar to *L. hamiltoni*, except the mean size and number of eggs laid, the mean maximum length of the larva, and the mean size of the newly metamorphosed frog tend to be somewhat smaller in *L. archeyi* (Bell 1978a). The larva is relatively inactive, has only the bases of the forelimbs covered by the branchial (gular) membrane during development and the tail fins are relatively narrow. Males have been observed brooding the eggs (Stephenson 1951, Bell 1978a), as in *L. hamiltoni*, but have evidently yet to be recorded brooding hatched larvae (but are likely to do so).

Systematics

The affinities of *L. archeyi* with *L. hamiltoni* have already been discussed. As noted by Bell (1978a) the suggested occurrence of hybrids between *L. archeyi* and *L. hochstetteri* is most unlikely and there is little evidence of subspecific differentiation between populations on Mt. Moehau (Fig. 3a) and elsewhere in Coromandel (see Stephenson 1961).

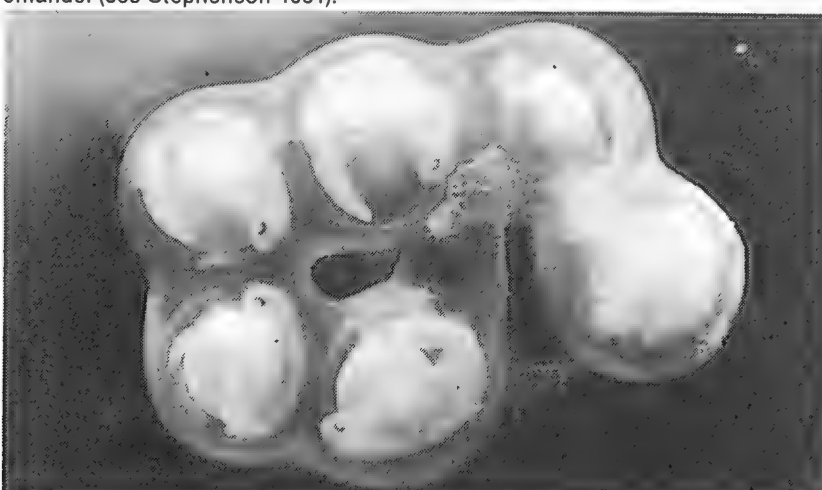


Figure 7 Intracapsular embryos of *Leiopelma archeyi* 4-5 weeks after laying. Note pigmented eyes, large yolk sacs, elongate vascularised tails that facilitate respiration, buds of forelimbs and hindlimbs, and gelatinous egg string enclosing the eggs, each of which is bounded by a vitelline membrane. Capsule widths 9-10 mm. Photo B.D. Bell.

THE INTRODUCED LITORIA SPECIES

Introduction

The Australian *Litoria* species are the most widespread and conspicuous frogs in New Zealand today, and hence they are the familiar frogs to most New Zealanders. Until Tyler's (1971) revision, they had been placed in the large genus *Hyla* along with tree-frogs of the Old and New Worlds. They belong to the family Hylidae (or Pelodryadidae), sharing adaptations to a climbing or arboreal mode of life, although two of the New Zealand species (*L. aurea* and *L. raniformis*) are secondarily more ground-dwelling in habit.

Of six *Litoria* species recorded in New Zealand only three have evidently naturalised (Bell 1977, 1982). European species, such as *Rana temporaria* and *Bufo bufo (= B. vulgaris)* were also liberated but failed to naturalise (Thomson 1922, Archey 1935).

Unlike the endemic frogs, the *Litoria* species occur in open wetland situations, such as swamps and marshes, and the margins of ponds and lakes, gathering to breed in generally still waters; the males have loud breeding choruses. They have the typical anuran life-cycle of frog spawn/free-swimming tadpole/frog. The three species are well documented in the Australian herpetological literature — two recent examples being Cogger (1975) and Barker and Grigg (1977).

The recent reports of *Litoria adelaidensis* and *L. gracilenta* in New Zealand (Bell 1982) remind us of the possibility of further introductions (accidental or deliberate). Also there is still a chance of discovering established populations of species not known to have naturalised here — after all, distribution surveys have not been exhaustive (Bell 1982). For example, Thomson (1922) has a tantalizing reference to 'a small green frog which was quite different from the common *Hyla aurea*' near Kaikohe, which he thought might be one of a surviving population of *L. caerulea* — just a possibility in the milder north?

THE WHISTLING TREE FROG, LITORIA EWINGI

This smallest of the naturalised *Litoria* species was evidently privately introduced to New Zealand by Mr W. Perkins who liberated frogs from Tasmania into a drain in Greymouth (Marriner 1907). In Australia *L. ewingi* occurs in eastern South Australia, Victoria, Tasmania and southern New South Wales and forms part of the '*Litoria ewingi* complex' of five closely related taxa *(L. ewingi, L. paraewingi, L. verreauxi verreauxi, L. verreauxi alpina, L. jervisiensis)* and other taxa still to be described (Watson, Loftus-Hills and Littlejohn 1971, Barker and Grigg 1977). Recent studies in New Zealand have confirmed that the introduced taxon is *L. ewingi* and there is little to suggest it is not of Tasmanian origin as reported by Marriner (Bell 1982).

Identification

Of roughly similar size to *Leiopelma* but distinguished by the external eardrum (tympanum) and horizontal pupil (Fig. 1). A dark-brown stripe from the eye to the shoulder (making the tympanum less obvious), yellow-orange posterior thighs, and lack of green colour distinguish *L. ewingi* from *L. aurea* and *L. raniformis* (as well as from *L. caerulea* and *L. gracilenta*). It is somewhat like *L. adelaidensis* (Fig. 8b) being predominantly light brown, but has a rounded (not pointed) snout and the dark-brown lateral stripe does not extend the length of the flank (as in *L. adelaidensis*). A less-dark brown '*ewingi* patch' usually occurs on the dorsum from between the eyes to the cloaca, flanked laterally by paler brown. Females tend to be larger than males (snout-vent lengths up to 42 mm and 36 mm respectively). The call of the male consists of a high-pitched, cricket-like "cree-cree-cree-cree-cree-cree-cree-cree-cree", so is not a croak (like *L. aurea* and *L. raniformis*), nor is it strictly a whistle — the Brown Tree Frog (cf. Gill 1973) might be a better descriptive name than Whistling Tree Frog.

Distribution

In the South Island *L. ewingi* is well distributed, and continues to spread, aided by further liberations. It is especially abundant on the West Coast but also occurs in parts of Nelson, Canterbury, Otago, Southland and on Stewart Island (Bell 1982). Initial North Island liberations were evidently in the coastal Manawatu in the late 1940's and the area is the species' North Island strong-hold today (Falla 1957, Wilson 1959, McCann 1961, Gill 1973, 1978, Bell 1982). Small populations have also been reported in the Coromandel, Auckland, Taranaki, Wanganui and Wellington districts (Bell 1982), doubtless the result of further liberations.

Habitat

L. ewingi occurs in habitats which are cool and moderately damp and which provide cover during the day. Accordingly, specimens are commonly found sheltering in clumps of monocotyledonous vegetation such as grasses; rushes; Sedges; flax (*Phormium*); raupo (*Typha*); toetoe and pampas grass (*Cortaderia*). In residential areas cultivated plants such as *Agapanthus* and *Kniphofia* are chosen (Gill 1973). In less modified habitats the frogs frequent margins of forest and scrub, they occur in swamps and wetlands, and in tussock grasslands as high as 1200 m in Westland (J. Dugdale, pers. comm.). Though capable of climbing, in the Manawatu they are seldom found more than a metre above ground according to Gill (1973).

In Australia, as in New Zealand, *L. ewingi* requires open water for breeding but is relatively independent of water at other times; many of its habitats are considerably distant from ponds or ditches (Gill 1973). Some breeding sites are ephemeral, drying out during the summer months; indeed, some winter breeding sites in Westland, for instance, are little more than large, shallow puddles.

Reproduction and Development

The reproduction and development of *L. ewingi* in New Zealand has been discussed by McCann (1960), Gill (1973, 1978), Aylward (1978) and Bell (1982). In the Manawatu district Gill (1978) found frogs called in every month of the year, at all air temperatures between 0 °C and 21 °C. Nuptial pads were observed on males over April-December, amplexus (in the pectoral position unlike *Leiopelma*) from May to November (probably also April), spawn from May to December (probably also April), tadpoles throughout the year and newly-metamorphosed frogs (about 12 mm snout-vent) from November to May; tadpoles grew and metamorphosed in about 4 months.

The grape-like spawn of *L. ewingi* is laid as bunches wound around submerged roots, stems, grass etc. The small, blackish or brownish eggs are enclosed in gelatinous spheres 3-4 mm across; these are larger than *L. aurea* and *L. raniformis.* The greyish-yellow embryos develop into black or brownish tadpoles, with well developed oral discs, that reach a maximum length of 50 mm, usually 35-45 mm (Bell 1982).

Systematics

Bell (1982) and Aylward (1978) confirmed the New Zealand taxon is indeed *L. ewingi,* and although Aylward concluded local populations had diverged morphologically and vocally from those in South East Australia, there is clear scope for more detailed study of populations within New Zealand and either side of the Tasman. Littlejohn (1982) discusses the '*L. ewingi* complex' in further detail.

THE GREEN FROGS, LITORIA AUREA AND L. RANIFORMIS

Since these two species are both members of the '*Litoria aurea* complex' of Australian species they will be considered together.

Although classified as 'tree-frogs' (*Litoria*), they seldom venture into arboreal situations and have only very small suction pads on fingers and toes. They are largely aquatic, and tend to move overland only during rain (Barker and Grigg

1977). In this respect they resemble the European frog, *Rana esculenta* — indeed this similarity to *Rana* gives *L. raniformis* its specific name.

Parker (1938) recognised two subspecies of *Litoria aurea: aurea* from coastal New South Wales and *raniformis* from further inland and further south. Moore (1961) later suspected *aurea* and *raniformis* might be valid species, but it was not until Courtice and Grigg (1975) overhauled the *Litoria aurea* complex of south-eastern Australia that the two taxa were indeed given specific status. Other species within the species-complex include *L. moorei* (S.W. Australia), *L. flavipunctata* (New England Tableland, N.S.W.) and *L. cyclorhynchus* (S.West Australia), following Barker and Grigg (1977), and Cogger (1979). A further *raniformis*-like taxon may be delineated from S.E. Australia (W.B. Sherwin, pers. comm.).

As noted earlier (Bell 1982), the occurance of both taxa in New Zealand was recognised in the early 1970's (Bell 1972), but not as distinct species until later (e.g. Bell 1977), following Courtice and Griggs' (1975) revision. The occurrence of the two species is now more generally recognised, aided no doubt by their differentiation in Robb (1980).

New Zealand authors had earlier recognised only the species *aurea* (formerly called *Hyla aurea*). Even after Parker's (1938) subspecific differentiation of the taxa, neither Barwick (1961), McCann (1961), Sharell (1966), Bell (1971a), Robb (1973), Crook (1974) nor Bull and Whitaker (1975) made this distinction. The excellent plate of Barwick (1961) clearly refers to *L. raniformis* (Fig. 1), as do those in Sharell (1966) and Crook (1974). Robb (1980) illustrates the two species in colour (Plate 4).

Identification

These two species are readily differentiated from endemic species by their larger size (snout-vent lengths up to ca. 90 mm), the external eardrum (tympanum) and horizontal pupils. They can be differentiated from all other *Litoria* species recorded in New Zealand by the yellow or whitish dorso-lateral fold running posteriorly from the eye (Figs 1 and 8a), together with the turquoise blue of the groin and posterior thighs (less evident in juveniles).

Bell (1982) discusses variation in New Zealand populations and the characters that differentiate the two species. *L. aurea* usually lacks a mid-dorsal stripe; has a mostly smooth dorsum with relatively few, if any warts; has a pale, dorso-lateral fold more or less continuous for most of its length; and has digital pads 1½ × wider than the digits (Fig. 8a). *L. raniformis* usually has a mid-dorsal stripe; a warty dorsum; a pale dorso-lateral fold broken into a series of blocks posteriorly; and digital pads about as wide as the digits (Fig. 8a). Generally *L. aurea* is slightly smaller (up to ca 80 mm snout-vent compared with ca 90 mm in *L. raniformis*), is less stocky and has less webbing on the hind feet.

The calls of the two species can be distinguished with experience. Both are typical frog-like croaks. Characteristically in *L. aurea* there is a four-note call with emphasis on the drawn-out initial phrase: "quaaaaaaaaaaaaaa-quaaaa-qua-quok". In *L. raniformis* there is a series of briefer but rising "quaaa-quaaa-quaaa-quaaa" notes mixed with repeated croaking "quor-ok-ok-ok" notes. Grigg and Barker (1973) have produced tape-recordings of the two species.

Distribution

L. raniformis is the more widespread species in New Zealand, occurring through much of the South Island and in the North Island from Taranaki, Rotorua and East Cape southwards, as well as in parts of the Auckland region (including Great Barrier Island), and locally in Northland (Bell 1977, 1982). *L. aurea* is known only from the northern portion of the North Island, including Northland, Auckland, Coromandel, the Bay of Plenty and the Waikato (Bell 1977, 1982). The two species are sympatric in some areas, such as in the Northland, Auckland and Rotorua districts.

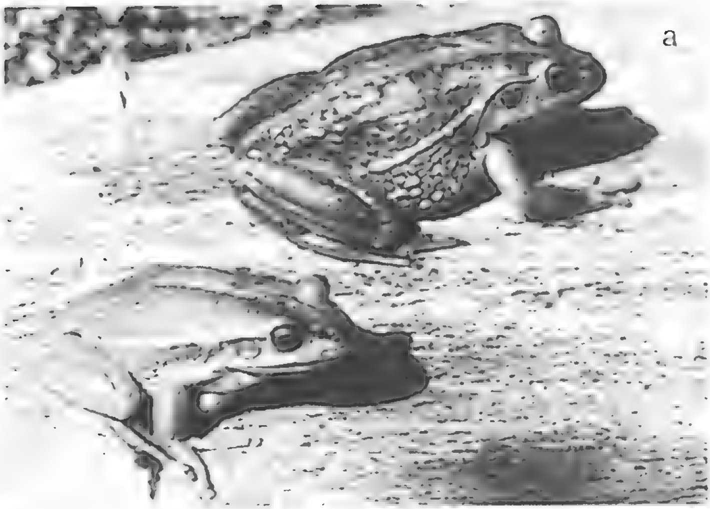


Figure 8(a) Two species of the *Litoria aurea* complex that have naturalised in New Zealand. *L. aurea* (foreground) has a relatively smooth dorsum without a mid-dorsal stripe, has a more-or-less continuous pale dorso-lateral stripe, has less hind-foot webbing and slightly larger toe discs than *L. raniformis* (background), which has a warty dorsum with mid-dorsal stripe, and a broken dorso-lateral stripe. Photo B.D. Bell.

Figure 8(b) A male *Litoria adelaidensis* (40 mm snout-vent) collected in New Plymouth by G.M. Fuller and W.D. Wilkinson in January 1981. Note dark and pale dorso-lateral stripes and pointed snout. Photo B.D. Bell.

Habitat

Both species occupy similar habitats, being found in the vicinity of lakes, pools and ponds, as well as in other wetland sites (e.g. swamps, marshes, ditches and streams). However, individuals may disperse away from fresh water at times; for example *L. raniformis* has been found in native forest in the Akatarawa Ranges, while *L. aurea* penetrates the margins of native forests in the Coromandel Ranges. Although often seen basking in water or waterside vegetation, these species may also be found under the dark cover of stones, logs or vegetation (where they may over-winter), often assuming a dark-brownish colour on the dorsal surface in such situations.

Reproduction and Development

In New Zealand choruses of *L. aurea* have been heard from September to February and *L. raniformis* from late August to February (Bell 1982) with most breeding activity in the late spring and early summer.

Nuptial pads are evident on males, amplexus is in the pectoral position and spawn has been recorded from September onwards. Unlike *L. ewingi*, the spawn of these species comprises mats of eggs which initially may lie on the surface of the water, but soon sink to the bottom or loosely adhere to underwater plants or debris. The egg capsules are smaller than *L. ewingi* (2-2.5 mm across) and the eggs have a black upper pole.

The embryos are initially dark greyish-black, becoming yellowish with darker brownish-grey abdomens; as pigment develops the tadpole may be dark velvety black-brown, or may remain lighter yellowish or greenish brown, depending on the environment. The oral disc is less developed than *L. ewingi,* and the tadpoles attain a larger size — generally up to 90-100 mm long though occasionally much more (130-150 mm). Freshly metamorphosed frogs are at least 20-30 mm (snout-vent) and take about 3 months to develop, maybe less at times (Bell 1982). There are no known criteria to differentiate eggs and tadpoles of the two species, though in very late metamorphosis the specific characters will become evident as the frog form is assumed.

Systematics

Although closely related, Courtice and Grigg (1975) determined that in Australian areas of sympatry 'each species was clearly recognisable and no evidence of hybridization was apparent'. In New Zealand areas of sympatry require study, though in general individuals have been readily assigned to one or the other species (Bell 1982). Thus, on present evidence, their taxonomic status as distinct though closely allied species appears appropriate. Bell (1982) outlines their taxonomic history, while Tyler (1982) presents a general review of the genus.

THE GREEN TREE FROG, LITORIA CAERULEA

Although apparently this species (Fig. 1) was liberated by the Agriculture Department in various locations from Nelson to Auckland over 1897-99 (Thomson 1922), there is no firm evidence to suggest it has naturalised in New Zealand, although a slight possibility of its surviving in the warmer north remains. An adult found in Wanganui in 1949 (McCann 1961) is not in itself sufficient evidence of the species survival — it may, for instance, have arrived with shipping or cargo like *Litoria gracilenta.* The large tadpoles from Inglewood and Puketaha ascribed by McCann (1961) to this species are evidently *L. raniformis/aurea* rather than *L. caerulea* (Bell 1982). Male *L. caerulea* call gruffly and loudly from breeding ponds at night and are unlikely to escape the attention of the observant naturalist. It occurs across the northern areas of Australia, also in southern New Guinea, being a frog of warmer sub-tropical or tropical climes. A fuller description of the species, its breeding and development and its status in New Zealand is given by Bell (1982).

THE SLENDER GREEN TREE FROG, LITORIA GRACILENTA

Bell (1982) reports only two records of this species in New Zealand, both single individuals at ports in Nelson and Auckland respectively (J. Dugdale, J. Robb pers. comm.). The Nelson specimen almost certainly originated from Brisbane and probably reached its destination after a sea journey of 4 weeks on the coaster "Holmedale"; this journey included visits to Onehunga, Lyttelton, Chatham Islands and Lyttelton again (R. Leary, in litt.). In Australia this attractively green, arboreal species occurs along the north-eastern coasts from a little north of Sydney to the tip of Cape York Peninsula (Cogger 1975). Like *L. caerulea*, therefore, it originates from a sub-tropical/tropical climatic region, in contrast to most of New Zealand's cool temperate climate. It seems therefore unlikely to naturalise in New Zealand. A relatively small species (up to 45 mm snout-vent), *L. gracilenta* has a uniform pale leaf green dorsal surface, a yellow ventral surface, yellow upper arms, yellow dorsal thighs, purple-brown posterior thighs and a bright orange iris. The hands and feet are strongly webbed and the discs are large. Further descriptions are given by Cogger (1975) and Barker and Grigg (1977), while the Nelson specimen is illustrated by Bell (1982).

THE SLENDER TREE FROG, LITORIA ADELAIDENSIS

Reports of this Australian species (Fig. 8b) in New Zealand come from New Plymouth where at least four males were heard calling at a lake in January 1981 (G.M. Fuller, W.D. Wilkinson, pers. comm.; Bell 1982). This species could well establish in New Zealand, since it occurs in the more temperate climatic zone of S.W. Australia. Investigations to date have failed to establish the presence of any females or any evidence of breeding — it is possibly a group of males which were imported and unofficially released in New Plymouth. Having a generally smooth, pale brown dorsum this species is most likely to be confused with *L. ewingi* but has a distinctly pointed snout; is somewhat larger (40-60 mm snout-vent); has posterior thighs brownish with orange-red spots; has a dark brown line along the side bordered below by a paler stripe (see Fig. 8b). Its call is a harsh, grating "Ka-ark" quite unlike other introduced *Litoria* species. Fuller descriptions are given by Copland (1957), Cogger (1975) and Barker and Grigg (1977). New Zealand specimens were identified by the author.

Acknowledgements

I wish to express my thanks to all those who have provided me with information on the New Zealand frogs including my colleagues in the DSIR Ecology Division, the Wildlife Service and in Australia; I am particularly indebted to all those who supplied me with distribution records, including many members of the New Zealand Herpetological Society. I also wish to thank the Secretary for Internal Affairs for granting me permits to carry out research on the endemic frogs.

References

ARCHEY, G. 1922: The habitat and life history of *Leiopelma hochstetteri*. *Records of the Canterbury Museum* 2: 59-71.

1935: Frogs in New Zealand. *Bulletin of the Auckland Zoological Society* 2: 5-8

AYLWARD, R.A. 1978: Aspects of the morphology and breeding biology of *Litoria ewingi* Dumeril and Bibron from the Manawatu. B.Sc. (Hons) dissertation, Massey University.

BARKER, J; G. GRIGG 1977: A field guide to Australian frogs. Rigby, Sydney.

BARWICK, R.E. 1961: Illustrations of the New Zealand frog fauna. *Tuatara* 8: 95-98.

BELL, B.D. 1971a: Frogs are worth looking for. *Pepeke, Newsletter of the New Zealand Herpetological Society* 17: 1-3.

1971b: The New Zealand frogs and their identification. *Pepeke, Newsletter of the New Zealand Herpetological Society* 17: 3-5.

1972: Record Form — New Zealand Frog distribution survey. Ecology Division, D.S.I.R.

1972: Progress report on the frog distribution survey. *Pepeke, Newsletter of the New Zealand Herpetological Society* 23: 1-4.

1977: Research uncovers more facts about rare native frogs. *Forest and Bird* 204: 12-17.

1978a: Observations on the ecology and reproduction of the New Zealand leiopelmid frogs. *Herpetologica* 34(4): 340-354.

1978b: Breeding New Zealand's archaic frogs. *Wildlife* 20(11): 512-514.

1981: The native frogs — rare and ancient endemics threatened by mining? *New Zealand Environment* 29 & 30: 30-31.

(1982): The amphibian fauna of New Zealand. *In* New Zealand herpetology: proceedings of a symposium held on 29-31 January 1980 at the Victoria University of Wellington. Editor D.G. Newman. N.Z. Wildlife Service, Department of Internal Affairs, Wellington.

BULL, P.C.; A.H. WHITAKER 1975: The amphibians, reptiles, birds and mammals. Chapter 5. *In* Biogeography and Ecology in New Zealand. Editor G. Kuschel. Junk, The Hague.

COGGER, H.G. 1975 (revised 1979): Reptiles and amphibians of Australia. Reed, Sydney.

COPLAND, S.J. 1957: Australian tree frogs of the genus *Hyla. Proceedings of the Linnean Society of New South Wales* 52: 9-108.

COURTICE, G.P.; G.C. GRIGG 1975: A taxonomic revision of the *Litoria aurea* complex (Anura: Hylidae) in south-eastern Australia. *The Australian Zoologist* 18: 149-163.

CROOK, I.G. 1974: Native Frogs. *New Zealand's Native Heritage* 1(10): 257-262.

CROOK, I.G.; I.A.E. ATKINSON; B.D. BELL 1971: Habitats of the frog *Leiopelma hamiltoni* McCulloch on Stephens and Maud Islands, Cook Strait. *New Zealand Journal of Science* 14: 1082-1093.

DAUGHERTY, C.H.; B.D. BELL; M. ADAMS; L.R. MAXSON 1981: An electrophoretic study of genetic variation in the New Zealand frog genus *Leiopelma. New Zealand Journal of Zoology* 8(4): 543-550.

DAUGHERTY, C.H.; L.R. MAXSON; B.D. BELL (1982): Phylogenetic relationships within the New Zealand frog genus *Leiopelma:* immunological evidence. *New Zealand Journal of Zoology* 9(2): 239-242.

FALLA, R.A. 1957: Sand country ecology symposium. Discussion. *Proceedings of the New Zealand Ecological Society* 5: 30.

FITZINGER, L.J. 1861: Eine neue Batrarhier-Gattung aus New-Seeland. *Verhandlungen der Zoologisch-botanischen Gesellschaft in Wien* II: 217.

FLEMING, C.A. 1975: The geological history of New Zealand and its biota. Chapter 1 *In* Biogeography and ecology in New Zealand. Editor G. Kuschel. Junk, The Hague.

GILL, B.J. 1973: Distribution and habits of the brown tree frog *Litoria ewingi* Dumeril and Bibron in the Manawatu-Rangitikei region. *Proceedings of the New Zealand Ecological Society* 20: 31-34.

1978: Notes on the distribution, activity and breeding of the whistling frog (*Litoria ewingi* Anura: Hylidae) in the coastal Manawatu district, New Zealand. *New Zealand Journal of Ecology* 1: 81-83.

GRAHAM, G. 1924: Note in 'The Patu Paiarehe' by John White. *Journal of the Polynesian Society* 33: 210-211.

GRIGG, G.C.; J. BARKER 1973: Tape-recordings: "Frog calls of S.E. Australia". Department of Zoology, University of Sydney.

LITTLEJOHN, M.J. (1982): *Litoria ewingi* in Australia: a consideration of indigenous populations and their interactions with two closely-related species. *In* New Zealand herpetology: proceedings of a symposium held 29-31 January 1980 at the Victoria University of Wellington. Editor D.G. Newman. N.Z. Wildlife Service, Department of Internal Affairs, Wellington.

McCANN, C. 1961: The introduced frogs of New Zealand. *Tuatara* 8: 107-120.

McCLAREN, J.M. 1898: On the geology of Te Moehau. *Transactions of the New Zealand Institute* 12: 494-498.

McCULLOCH, A.R. 1919: A new discoglossid frog from New Zealand. *Transactions of the New Zealand Institute* 51: 447-449.

MARRINER, G.R. 1907: On the presence of another Australian frog in New Zealand. *Transactions of the New Zealand Institute* 39: 144-149.

MOORE, J.A. 1961: The frogs of eastern New South Wales. *Bulletin of the American Museum of Natural History* 121: 149-386.

NEWMAN, G.D. 1977: Hamilton's frog. *Wildlife — a review* 8: 48-53.

(1982): A management plan for Hamilton's frog on Stephens Island. *In* New Zealand herpetology: proceedings of a symposium held 29-31 January 1980 at the Victoria University of Wellington. Editor D.G. Newman. N.Z. Wildlife Service, Department of Internal Affairs, Wellington.

OGLE, C.C. 1980: Wildlife and wildlife habitat of Great Barrier Island. *New Zealand Wildlife Service, Fauna Survey Unit Report* 24.

PARKER, H.W. 1938: The races of the Australian frog *Hyla aurea* Lesson. *Annals and Magazine of Natural History* (11) 2(9): 302-305.

ROBB, J. 1973: Reptiles and Amphibia. Chapter 5 *In* The Natural History of New Zealand. Editor G.R. Williams. Reed, Wellington.

1980: New Zealand amphibians and reptiles. Collins, Auckland.

SAVAGE, J. 1973: The geographic distribution of frogs: patterns and predictions. *In* Evolutionary biology of the anurans. Editor J.L. Vial. University of Missouri Press, Columbia.

SCHIPPER, C. 1970: The frogs of New Zealand. *New Zealand Herpetological Society Newsletter* 6: 3.

1971: Pepeke, an old name for a young newsletter. *Pepeke, Newsletter of the New Zealand Herpetological Society* 17: 6-7.

SHARELL, R. 1966 (revised 1975): The tuatara, lizards and frogs of New Zealand. Collins, London.

SMITH, S.P. 1921: Letter in *New Zealand Journal of Science and Technology* 3: 308 (with note by J.A. Thomson).

STEPHENSON, E.M. 1960: The skeletal characters of *Leiopelma hamiltoni* McCulloch, with particular reference to the effects of heterochrony on the genus. *Transactions of the Royal Society of New Zealand* 88: 473-488.

1961: New Zealand native frogs. *Tuatara* 8: 99-106.

STEPHENSON, E.M.; E.S. ROBINSON; N.G. STEPHENSON 1972: Karyotypic variation within the genus *Leiopelma* (Amphibia: Anura). *Canadian Journal of Genetics and Cytology* 14: 691-702.

1974: Inter-specific relationships of *Leiopelma* (Amphibia: Anura): further karyological evidence. *Experientia* 30: 1248-1250.

STEPHENSON, E.M.; N.G. STEPHENSON 1957: Field observations on the New Zealand frog *Leiopelma* Fitzinger. *Transactions of the Royal Society of New Zealand* 84: 867-882.

STEPHENSON, N.G. 1951: Observations on the development of the amphicoelous frogs, *Leiopelma* and *Ascaphus*. *Journal of the Linnean Society (Zoology)* 42: 18-28.

1955: On the development of the frog *Leiopelma hochstetteri* Fitzinger. *Proceedings of the Zoological Society of London* 124: 785-795.

STEPHENSON, N.G.; E.M. THOMAS 1945: A note concerning the occurrence and life-history of *Leiopelma* Fitzinger. *Transactions of the Royal Society of New Zealand* 75: 319-320.

STEVENS, G.R. 1980: New Zealand adrift. Reed, Wellington.

THOMSON, A.S. 1853: On the discovery of a frog in New Zealand. *Edinburgh New Philosophical Journal* 55: 66-69. Reprinted in 1920 in *New Zealand Journal of Science and Technology* 3: 220-222.

THOMSON, G.M. 1922: The naturalisation of animals and plants in New Zealand. Cambridge.

TURBOTT, E.G. 1937: Some observations on the distribution and anatomy of *Leiopelma hochstetteri* Fitzinger. M.Sc. thesis, University of Auckland.

1942: The distribution of the genus *Leiopelma* in New Zealand with a description of a new species. *Transactions of the Royal Society of New Zealand* 71: 247-253.

1949: Discovery of the breeding habits of *Leiopelma hochstetteri* Fitzinger. *Records of the Auckland Institute and Museum* 3: 373-376.

TYLER, M.J. 1971: The phylogenetic significance of vocal sac structure in hylid frogs. *University of Kansas Publications, Museum of Natural History:* 319-360.

(1982): The hylid frog genus *Litoria* Tschudi: an overview. *In* New Zealand herpetology: proceedings of a symposium held on 29-31 January 1980 at the Victoria University of Wellington. Editor D.G. Newman. N.Z. Wildlife Service, Department of Internal Affairs, Wellington.

WATSON, G.F.; J.J. LOFTUS-HILLS; M.J. LITTLEJOHN 1971: The *Litoria ewingi* complex (Anura: Hylidae) in south-eastern Australia. I. A new species from Victoria.

WILLIAMS, G.R.; D.R. GIVEN 1981: The red data book of New Zealand. Nature Conservation Council, Wellington.

WILSON, R.A. 1959: Bird islands of New Zealand. Whitcombe and Tombs, New Zealand.

A REVIEW OF THE HERPETOFAUNA OF SOUTHERN NEW ZEALAND WITH SOME TAXONOMIC CONSIDERATIONS

By Bruce W. Thomas, Ecology Division,
Department of Scientific and Industrial Research
Private Bag, Nelson, New Zealand.

Abstract:
Distributions, from approximately 45 degrees latitude southwards, are discussed for *Litoria ewingi, L. raniformis, Sphenodon punctatus, Leiolopisma nigriplantare, L. otagense, L. grande, L. lineoocellatum, L. chloronoton, L. acrinasum, Hoplodactylus maculatus, H. granulatus, H. rakiurae and Heteropholis gemmeus;* some descriptions are given. From morphological and ecological evidence it is suggested that the taxonomic status of *L. otagense* form *waimatense* be reexamined. Some conservation and management problems and priorities for herpetological research in the region are discussed.

Introduction:

New Zealand lacks the diversity of amphibians and reptiles found in other parts of the world but the "primitive" nature of many endemic species makes them scientifically extremely interesting. The tuatara *(Sphenodon punctatus)* and to a lesser degree the native frogs *(Leiopelma* spp.) are well known worldwide and have been extensively studied, whereas the lizards have received comparatively low research priority. However, this situation may change now that recent legislation affords legal protection to all except four common species of lizards (*Sphenodon* and *Leiopelma* have been protected for many years).

Some of the biggest gaps in the knowledge of the herpetofauna occur in the southern part of New Zealand (including Otago, Fiordland, Southland and Stewart Island) and I review here the species known from approximately 45 degrees latitude southwards. Several of our rarest and least known lizards are endemic to this region, and three species, *Hoplodactylus rakiurae, Leiolopisma grande* and *L. otagense,* are listed in the "Red Data Book of New Zealand" (Williams and Given, 1981).

Frogs:

Two species of introduced Australian frogs occur in the region, *Litoria ewingi* and *L. raniformis;* both have acclimatised well to New Zealand conditions. Being insectivorous and often abundant they may have had a considerable impact on native invertebrates. They are eaten by some birds and may be an important component in the diet of species such as the white-faced heron *(Ardea novaehollandiae)* and the Australasian harrier *(Circus approximans).*

Litoria ewingi (Dumeril and Bibron). The whistling frog, as it is know locally, is well established in several areas within the region (Fig. 1). It is found in a variety of habitats, including farmland, forest and even alpine environments. It is widespread over a large area from Te Anau, south to the Waiau and east to the Catlins district. Outlying populations are known from Queenstown, the Waikaia/Wendonside districts, and at Masons Bay on Stewart I.

This frog was apparently unknown in the Catlins before the late 1950s or early 1960s when many *L. ewingi* eggs and a few adult frogs (from the West Coast) were released into several swamps in the Tahakopa Valley by N.A. Dewe (pers. comm.). Others were released in Progress Valley by P. Soderstrom (pers. comm.) during November 1971. The species thrived and spread rapidly from both liberation points (Dewe/Soderstrom, pers. comm.) and is now found throughout the Tautuku and Slopedown State Forests.

Populations of *L. ewingi* near Queenstown and in the Waikaia/Wendonside district are probably the result of similar liberations. Many people seem intrigued by these small (25-40 mm) pale-fawn or brown frogs, and frequently 'take some home' to areas without them. However, on Stewart I. *L. ewingi* were released at Masons Bay (by the Leask family) to try to control mosquitos (C.W. Sampson, pers. comm.). This colony, although established since the 1950s, has not widely dispersed. The species was also reported at Halfmoon in 1975 by D. Coomes but does not seem to have become established.

Litoria raniformis (Keferstein). The few records for this species show a distribution in the region (Fig. 1) that is probably very different to its actual range and much more information is needed to obtain a realistic map.

This large (60-80 mm) green frog is usually an open country species, but a report of two *L. aurea (= L. raniformis?)* at Lake Orbell, 90 m a.s.l. in the Mur-

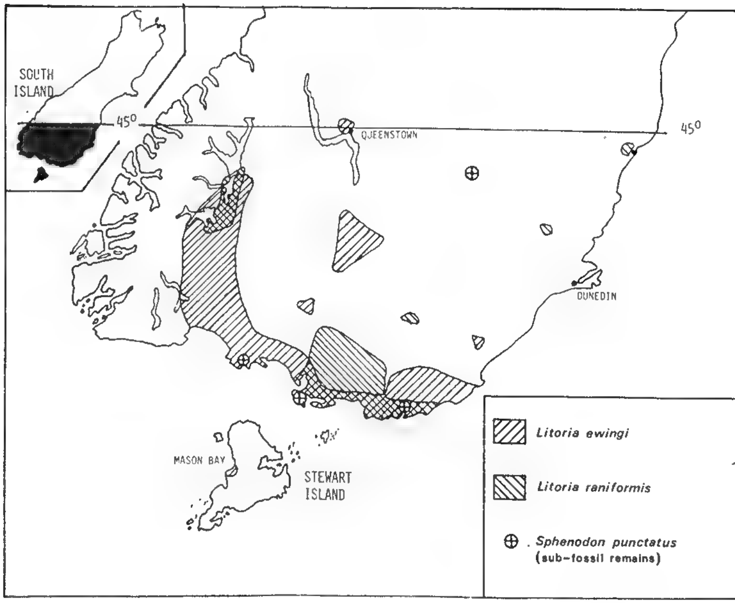


Fig. 1 Distribution of frogs and tuatara

Fig. 3 *Leiolopisma otagense:* (above) form *otagense* (Central Otago); (below) form *waimatense* (Wairau River).

Distibution of skinks

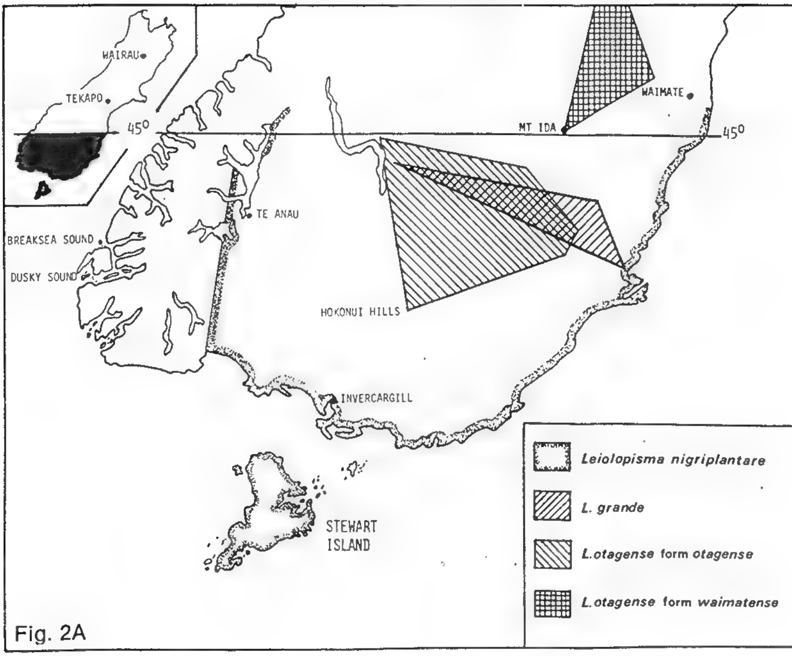


Fig. 2A

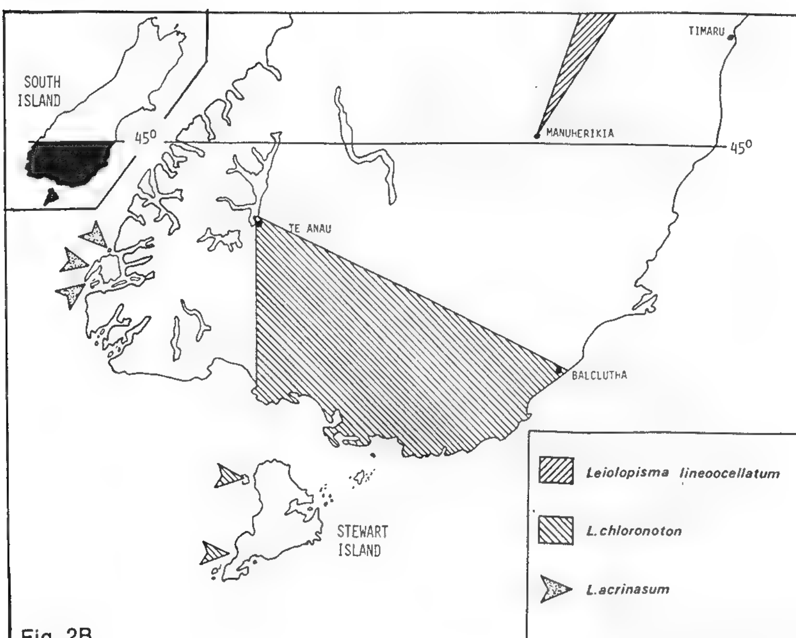


Fig. 2B

chison Mountains (Miers, 1963) is particularly interesting. Natural dispersal to Lake Orbell would have required them to travel a considerable distance through forest and there seems little reason to suspect dispersal through human agency because of the inaccessibility of the area.

Tuatara:

Sphenodon punctatus Gray. Sub-fossil remains are the only evidence of tuatara from the region (Fig. 1). Crook (1975) shows records inland from Oamaru and at Bluff and there are remains in the Southland Museum from Wakapatu and Waikawa (L. Hazely, pers. comm.).

Skinks:

Five species of skink (genus *Leiolopisma)* have been identified from the region, and two further taxa possibly extend to 45 degrees latitude in their southernmost distribution. All are diurnal.

Leiolopisma nigriplantare maccanni (Peters). The common skink is a small (approximately 130 mm) brown, striped skink that varies considerably in colour pattern. Miller and Miller (1981) noted two distinctive colour forms from Otago — specimens from schist country had a speckly mottled appearance, whereas those from grassland were plain brown with longitudinal stripes.

The species is widespread in the region (Fig. 2A), occupying a variety of open habitats from seashore to 1500 m in the alpine zone in the Murchison mountains. Highest densities occur in dry, stony areas where there is plenty of cover. On Stewart I. it is often found in damp, almost boggy, areas with short *Calorophus-Gleichenia* vegetation the only cover.

Leiolopisma otagense McCann. Within this species two forms are currently recognised, *'otagense'* and *'waimatense'* (Hardy, 1977), which were first described as sub-species of *L. grande* by McCann (1955). Hardy (1977) separated them from *L. grande,* and included both under *L. otagense.* With no ecological data and few specimens he was only prepared to recognise *'waimatense'* as a form of *L. otagense* rather than retain its sub-specific status. With more specimens and some ecological observations available, there are grounds to reevaluate the status of *'waimatense'.*

L. otagense form *otagense,* the Otago skink (Fig. 3) is the largest of the South Island skinks, a very robust species up to 315 mm total length (live male, from Central Otago — P. Mainwaring collection). The colour of *'otagense'* is basically black or dark brown with a series of large cream or greenish-tinted blotches extending along the body dorsolaterally, sometimes merging into almost continuous stripes on the tail. Smaller blotches are scattered, often irregularly, on dorsal and lateral surfaces and limbs. The ventral surface is light grey, mottled with patterns of numerous dark spots and blotches. The soles of its feet are dark brown.

Little is known of its present distribution (Fig 2A) but museum specimens indicate that *'otagense'* occurred widely in the dry area of Central Otago (Hardy, 1977) where it "lives on rocky outcrops in undeveloped or semi-developed tussock land" (Miller and Miller, 1981). A good colour photograph of what is undoubtedly *'otagense'* was taken by P. Gay in the Hokonui Hills (Fig. 2A), well south of the previous known range. Several of these skinks were seen amongst outcrops of conglomerate rock on a boulder strewn north facing slope (P. Gay, pers. comm.).

'Otagense' is diurnal, emerging periodically from the shelter of the deep cracks and crevices in the horizontally-layered schist tors to bask on the sunny ledges (McDowall, 1978; Miller and Miller, 1981). Its food consists of a variety of invertebrates and fruits. In captivity it eats cicadas, crickets, beetles, moths, and flies (Mainwaring, 1979). An adult *L. otagense* was observed by P. Mainwaring (pers. comm.) eating berries off a bush lawyer vine *(Rubus* sp.); *L. otagense* droppings crammed full of seed were found over a wide area in one Central Otago Valley during April 1978 by D.A.R. Newman (pers. comm.).

L. otagense form *waimatense,* the scree skink (Fig. 3) is moderately robust and grows to an overall length of 260 mm (live female, Lake Tekapo). It is light golden brown or grey in colour with broken, narrow, black banding across the back and down the sides (some variation occurs between specimens) with, usually, only a few black spots on the tail. Pale dorsolateral lines occur on many specimens. The plain undersurface is usually an orangey-pink (of varying shades) or very occa-

sionally grey, sometimes with sparsely scattered small black spots under the chin or throat. The soles of its feet are light brown to black.

At present two populations of this distinctive skink are known. One is from the upper Wairau River (Marlborough) and the other from Lake Tekapo, South Canterbury (Fig. 2A - inset). Probably more colonies will be discovered in the extensive, low-rainfall, semi-arid, tussock country east of the main divide in the central South Island - early museum specimens were collected from Lake Coleridge, Waimate and several unspecified localities in South Canterbury and Otago (McCann, 1955; Hardy, 1977).

In contrast to *'otagense'*, form *waimatense* lives in relatively unstable habitats. The Wairau population seems to be concentrated in the bottom of dry watercourses which dissect the lower part of an extensive scree - perhaps because the accumulations of larger rocks left when the finer gravels were washed away provide a more stable environment than the surrounding moving mass of stones. The animals would need to vacate these channels during rainy periods. The Tekapo colony was found in a long, narrow erosion scar on a steep tussock-covered hillside. They too were living under the bigger stones accumulated at the foot of the steep-sided gully, but here they were well above the watercourse (D.A.R. Newman, pers. comm.). Although the macro-habitats of these two populations are somewhat different, their micro-habitats are very similar.

Few ecological observations of *'waimatense'* have been recorded. Two were found on the edge of the scree at the Wairau colony, but none were found in the surrounding vegetated area, although it seemed ideal habitat with large rocks and heaps of stones scattered through tussock and tangles of matagouri *(Discaria toumatou)* and introduced briar *(Rosa rubiginosa)* (Thomas, 1977). Here there seemed to be much more potential food (grasshoppers, butterflies, cicadas, spiders, isopods) especially for such a large skink which readily eats these things in captivity. Why *'waimatense'* is so localised and appears to require such a specialised habitat is not obvious. In captivity, as well as eating a variety of insects it also takes slugs, worms and even ripe red currants (an indication that it may forage for berries in the wild). A captive male *'waimatense'* ate an adult *Heteropholis stellatus* (approximately 130 mm) by swallowing it head first; they may therefore also take the sympatric lizards *L. nigriplantare* and *H. maculatus* in their natural environment.

'Waimatense' is of much lighter build than *'otagense'* and this is especially noticeable around the base of the tail (Fig. 3). It also has a more erect posture than *'otagense'*, which tends to move with head low and body hugging the substrate. The colour patterns of both these forms are well suited to their particular habitats. The yellow or greenish blotching on the dark background colour of *'otagense'* nicely matches the yellow and light green lichens growing on the schist tors and to some extent the weathering on the darker rock substrate, whereas the broken pattern on *'waimatense'* creates the stippled effect of contrasting light and shade amongst the stones of the scree environment.

McCann (1955) described *'otagense'* from a single Canterbury Museum specimen; no specimen number was quoted but some collection details were given. Subsequently, G.S. Hardy located this holotype in the National Museum of New Zealand. Because a numbered label attached to the specimen bore the prefix of that museum's reptile collection (G.S. Hardy, pers. comm.) he referred to it in Hardy (1977) as NMNZ R33. However, according to the museum's reptile register this number is assigned to a gecko specimen - since the 'otagense' holotype is currently missing the problem cannot now be checked. It is interesting that another *'otagense'* specimen, NMNZ R 302, has an additional label ('dymo-tape') numbered R45 attached, which also bears no relation to the register entries.

McCann (1955) considered *'waimatense'* to be the largest of the *L. grande* subspecies, probably because his only *'otagense'*, the holotype, was a smallish specimen with an axilla-groin measurement of only 51 mm (the only measurement given by him). This is less than several of the *'waimatense'* (a-g 55 mm for 3 live females, Wairau and Tekapo) examined during this study. Also, two of the nine specimens he assigned to *'waimatense'* are in fact large *'otagense'* (NMNZ R207 and R302, axilla-groin 60 mm and 63 mm respectively). Robb (1980) follows McCann's (1955) classification and also considers *'waimatense'* to be the largest of

the *"L. grande"* sub-species, giving a total length measurement of almost 300 mm, with snout-vent 125 mm. No reference is made to specimens but in the colour description she stated that *"L. grande waimatense"* has a slightly mottled undersurface. From specimens examined in this study the difference in belly coloration seems an easy and reliable method to differentiate between the two taxa — *'waimatense'* has a plain-coloured undersurface and that of *'otagense'* is mottled. Because of this confusion with 'otagense', previous descriptions of *'waimatense'* have included characters of both taxa. Hardy (1977) confused the two only in the colour description in which he largely followed McCann (1955), and Hardy (pers. comm.) did not examine NMNZ R207 and R302 during his study. The Wairau and Tekapo *'waimatense'* populations were not known when he wrote his paper.

Martin (1929) observed large skinks on Mt Ida (Otago) and from the size given (up to one foot) by Martin for his "common rock skink *(Lygosoma grande)"*, Hardy (1977) concluded that they were form *'otagense'*. The habitat description given by Martin is, however, more typical of that now known for *'waimatense'* and I believe this was the taxon more likely to have been observed by him on Mt Ida. McCann's (1955) type locality for *'waimatense'*, Waimate, is only approximately 75 km northeast of Mt Ida (Fig. 2A), also it is likely that the type specimen (NMNZ R92) was collected from somewhere inland of the township. Whichever form Martin saw it is clear that *'otagense'* and *'waimatense'* are not as geographically separated (Fig. 2A) as Hardy's (1977) and Robb's (1980) maps indicate.

It is unfortunate that Hardy (1977) had no live *'waimatense'* available for electrophoretic analysis. He suggested that a divergence of the two forms probably resulted from isolation of the ends of a north-south cline during the last glaciation *('otagense'* on Otago Pensinsula and *'waimatense'* on Banks Peninsula); although the known distribution in Otago and Canterbury at the time of his study did not coincide exactly with apparent Pliestocene refuge areas. Equally, if *'otagense'* and *'waimatense'* have evolved from a single ancestral form, they may have diverged by occupying different niches. At this point, however, further research is needed to establish their true phylogenetic relationship and correct taxonomic status.

Material examined. *L. otagense* form *otagense* (total 27 specimens) — NMNZ R207, R302, R1595, R1834-5, R.1909; Ecology Division, DSIR, (housed at National Museum) S420-21, S813, S839, S1509, S1512-13, S1520-3; 10 live specimens. *L. otagense* form *waimatense* (total 26 specimens) — NMNZ R92, R1827-33; 18 live specimens.

Leiolopisma grande (Gray). This is the rarest of the South Island skinks and is currently known from only one area, recently documented by Miller and Miller (1981). Locality data from the few museum specimens (Hardy, 1977) indicate that the species was once widespread in Otago (Hardy and Whitaker, 1979). Although distribution maps in Hardy (1977) and Robb (1980) suggest that it is separated geographically from *L. otagense* the discussion in Hardy (1977) and Fig. 2A show that they occur sympatrically in some places.

L. grande is more slender-bodied than *L. otagense* and grows to at least 260 mm (G. Loh, pers. comm.) in length. The back, upper sides and dorsal surface of the limbs are black, with a multitude of cream or greenish flecks arranged in numerous rows along the back and to a lesser extent on the sides and legs. The lower sides are cream-coloured with black blotches and the belly is cream with some indistinct black markings, mainly on the throat. The head has much denser markings, which give it a golden hue (Miller and Miller, 1981 and pers. obs.).

It is a very active, agile and inquisitive skink, and does not remain under cover for long, even when being pursued (Miller and Miller, 1981). Like form *'otagense'*, *L. grande* inhabits crevices on schist outcrops but seems to prefer more vegetated areas (Miller and Miller, 1981). It has also been observed up to 10 metres from the rock tors in the surrounding tussock vegetation, and several were seen together in a spaniard plant (*Aciphylla* sp.) (N. Hellyer and G. Loh, pers. comm.). The yellow, linear colour pattern seems well suited to this habitat yet it serves as a good camouflage on the rocks as well. It is interesting that *L. grande* and form *'otagense'* have developed similar basal colourations but with different patterns to suit slightly different habitats.

Fig. 4 *Leiolopisma acrinasum:* (left) adult (Dusky Sound); (right) habitat (type locality).

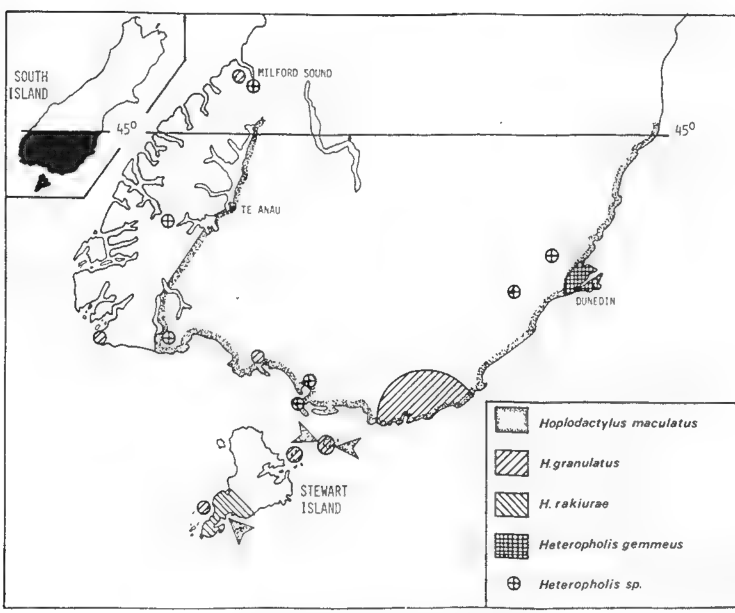


Fig. 5 Distribution of geckos.

L. grande may be threatened by pasture development. A dramatic decrease in numbers of the sympatric lizards *L. nigriplantare* and *H. maculatus* from extremely dense populations in the undeveloped tussock land areas to those in semi-developed places and cultivated pasture was noted by G. Loh (pers. comm.). Miller and Miller (1981) comment that the rocky tors where they found *L. grande* are in undeveloped tussock country. A change of farming practice in the area, from low density, set-stocking (sheep and cattle) to winter fodder cropping with greater concentrations of animals, is cause for much concern (N. Hellyer, pers. comm.). Elsewhere when such development has occurred the tors have been left intact but changes in the overall ecological associations of the area, particularly with regard to the insect fauna, will no doubt be quite dramatic and could adversely affect these skinks. Also, because the tors are on higher, drier ground, farm stock will tend to congregate at these places after rain when the low-lying areas begin to pug (N. Hellyer, pers. comm.). G. Loh (pers. comm.) observed that lizards had a marked preference for clean rock habitat and that buildups of dung, dust and silting on or under the rocks, notably reduced the use of these sites by all species found in the area.

Leiolopisma lineoocellatum (Dumeril & Dumeril). The spotted skink is a robust lizard up to approximately 200 mm (s-v 111 mm) with a brown or iridescent green back flecked with small, pale, black-edged spots. A dark band along the upper sides is flecked with black. The belly is plain, varying in colour from grey through pink to brick red. The species inhabits various open (usually stony) habitats from sea level to alpine areas (up to 1700 m — Bull and Whitaker, 1975).

Big skinks from the Manuherikia area (Fig. 2b) were identified from photographs as *L. lineoocellatum* which, if correct, extends the range of the species considerably southwards (Miller and Miller, 1981). It had previously been recorded only as far south as the Lake Alexandrina/Tekapo region (Anon, 1980).

Leiolopisma chloronoton Hardy. The green skink is very similar in size and colour to *L. lineoocellatum,* but differs in several morphological characters. Electrophoretic studies have also revealed marked differences (Hardy, 1977).

L. chloronoton occupies well vegetated (tussock grassland/divaricating shrubland) habitats with scattered stone and debris retreats. At Te Anau, A.H. Whitaker (pers. comm.) found them in small chambers at the end of tunnels dug in moist loamy soil underneath partially buried stones. On Codfish I. near Stewart I. a population lives on sand dunes where it is mainly confined to areas with a thick cover of grass or low divaricating shrubs. Further south on Big I., in the Boat Group, it is common in warm, grassy clearings (under wood, stones and tin around the muttonbirders' huts) (R. Nilsson, pers. comm.).

An early *L. chloronoton* specimen in the Otago Museum (OM A98.77) was reputedly collected from Timaru, but this is a dubious record. In recent years the species has not been recorded north of a line from approximately Te Anau to Balclutha (Fig 2B) (Hardy, 1977). Similarly, although they are abundant on some islands off Stewart I. none have recently been recorded from Stewart I. — in fact, the only *L. chloronton* specimens reputedly from there (OM A98.90 and Southland Museum E81-2) are very old specimens also of dubious origin.

Leiolopisma acrinasum Hardy. The Fiordland skink (Fig. 4) is a sleek (180-200 mm), dark brown to black skink, given an overall greenish tinge by small yellow or green flecks scattered over the dorsal surface. The ventral surface is mottled with greenish grey and black.

L. acrinasum has been found on II small islands and islets off Five Fingers Peninsula and in the entrances to Breaksea and Dusky Sounds (K. Morrison, 1982 and pers. obs.) in southwest Fiordland (Fig. 2B). They live mainly on exposed shoreline rock platforms (Fig. 4), a harsh environment subjected to strong winds and much salt spray; one islet must be almost totally awash during some of the frequent and violent storms in the area. As few loose stones are available, the lizards use cracks and crevices as refuges and when threatened they often dive into the numerous brackish splash pools to escape danger. Generally, they do not move far into the surrounding short, herbaceous vegetation and were never seen under the taller Dracophyllum-Olearia scrub. The type locality has a very dense population of *L. acrinasum,* which is no doubt directly attributable to the influence of the seal colony there. This was the only place the skinks were seen any distance from the shoreline rocks, when they congregated around (or on) dead

seal pups to catch the numerous blowflies attracted to the corpses. One *L. acrinasum* regurgitated several amphipods (Thomas, 1976) and in captivity they take a variety of invertebrates. None were seen venturing from the shelter of the crevices at night to feed on the myriad of nocturnal invertebrates crawling over the rocks. On islands without seal colonies the skink populations were notably sparse in comparison, and on adjacent islands with suitable skink habitat but with either rats or wekas *(Gallirallus australis* — a large, flightless rail) present, no skinks were observed at all (see below).

Geckos:

Four geckos have been recorded from the region: three species of *Hoplodactylus,* an essentially nocturnal genus, and the other a species in the genus *Heteropholis,* which is diurnal. The taxonomy of New Zealand Gekkonidae is in need of major revision, particularly the green tree geckos of the genera *Naultinus* and *Heteropholis.* Most contemporary New Zealand herpetologists consider *Heteropholis* should be relegated to synonymy with *Naultinus* (Thomas, in press). The species in these genera have allopatric distributions (Bull and Whitaker, 1975) and the status of some extant taxa is in doubt. For this reason unsubstantiated records of green geckos will be here referred to as *Heteropholis* sp.

Hoplodactylus maculatus Boulenger. The common gecko is a small species (approximately 130 mm), basically a drab grey/green mottled colour but there is considerable variation in pattern. It is a widespread species (Fig. 5), occupying a variety of habitats from shoreline to mountain tops. Although generally considered to be terrestrial and living in rocky habitats or under logs and debris, it is also found in forests, under bark or in holes up trees.

H. maculatus can occur in extremely high densities (Whitaker, in press), particularly in drier areas such as the schist country of Central Otago where groups of five or six are commonly found (Miller and Miller, 1981) and once, more than 20 were discovered together under one rock (G. Loh, pers. comm.).

The species occurs in similar densities on many offshore islands (pers. obs.) In Foveaux Strait they occur on Bird I. (in high numbers — L. Henderson, pers. comm.), and Green I. (L. Hazely, pers. comm.) and a single specimen was collected from a small island in Port Pegasus (Thomas, 1981). I am unaware of any recent specimens from mainland Stewart I., the only specimens reputedly from there are old ones in Southland Museum (SME 81.3/1-3), which are of dubious origin. Records in Bull and Whitaker (1975) were in fact from offshore islands (A.H. Whitaker, pers. comm.) and although Robb (1980) includes Stewart I. in the species distribution map she only specifically mentions the occurrence of *H. maculatus* on offshore islands. The only material from this area examined by Robb and Rowlands (1977) was from Bird I. and Green I. (J. Robb, pers. comm.).

Hoplodactylus granulatus (Gray). (Includes *Heteropholis nebulosus,* see Thomas 1981). The forest gecko grows up to 200 mm, and is predominantly arboreal. Although its basic colouration is generally mottled drab greys and browns, some forest geckos can have spectacular well defined patterns with reddish or yellow blotches dorsally.

There are few distribution data for *H. granulatus* from within the region (Fig 5) but it probably occurs in most native forest and scrubland areas. It is relatively common throughout the Catlins district (Tautuku, Catlins River, Chaslands, Longbeach, Progress Valley, Haldane — P. Soderstrom, pers. comm.), and an Otago museum specimen came from Riverton, west of Invercargill. A specimen (ED G 259) was collected from the Sinbad Valley, Milford, and in southern Fiordland, brown geckos with orange mouths (almost certainly *H. granulatus)* were reported at Puysegur Point (R.A. Walter, pers. comm.). Similarly a large brown gecko seen on Ruapuke I. (W. Black, pers. comm.). could have been *H. granulatus* as the species is known from nearby Zero Rock, Womens I., and Herekopare I. (Adams and Cheyne, 1969) and several other islands around Stewart I. (Thomas, 1981).

Hoplodactylus rakiurae Thomas. Although the harlequin gecko is the smallest *Hoplodactylus* (125 mm) it is certainly not insignificant. In contrast to the usual drab browns and greys of the other species, *H. rakiurae* is extremely colourful with a complex pattern of green and white elliptical markings on a usually rich brown basal colour (see colour photograph in Thomas, 1981). Within the species the colour pattern seems remarkably constant and colour variation is mainly con-

fined to differing tonings of the darker basal colours. The unmarked plain brown toes are a contrast to the highly patterned body.

The cryptic coloration of the harlequin gecko seems equally well suited to both terrestrial and arboreal activity in its habitat of windswept subalpine scrub and outcropping exfoliating granite. The few seen (16) have all been found on the ground, but those in captivity frequently climb into the foliage to bask or forage. Although essentially nocturnal, the *H. rakiurae* in captivity are noticeably more active during the day than other *Hoplodactylus.* This, no doubt, is the reason it has developed the bright coloration more typical of diurnal geckos (some *Heteropholis stellatus,* from the Nelson Lakes area, are very similarly patterned to *H. rakiurae).* Other characters of *H. rakiurae,* such as the narrow digits and irregularly sized, pointed scales, reinforce the hypothesis that there is a close relationship between the two groups of New Zealand geckos *(Hoplodactylus* and *Naultinus/Heteropholis),* which are currently considered to have evolved from a single ancestral stock (Bull and Whitaker, 1975 and Thomas, in press). It will be most interesting to see if newly born *H. rakiurae* have the same colour pattern as the adults, or whether they are a uniform green with white spots like juvenile *Heteropholis* (even those from predominantly brown parents).

H. rakiurae has been found only in southern Stewart I. (Fig. 5). All locality records lie within the area of the kakapo *(Strigops habroptilus* — a parrot) research programme of the New Zealand Wildlife Service, because of the intensity of research effort there. However, it must surely occur beyond this, at least to the Rakeahua R. There seems little reason why it should not occour in northern Stewart I. as well, but as the northern part of the island has the only settlement (Oban) and receives the most "traffic" (trampers, shooters, field officers), it is surprising that there have been no reports from there. Likewise, it is interesting that it avoided detection by the scientific community for so long (first recorded in 1969 and described in 1981) when they must have been seen frequently during the tin-mining operations late last century.

Heteropholis gemmeus McCann. The jewel gecko is a diurnal species which grows to approximately 170 mm. Its colour and long, slender, prehensile tail and narrow toes are well suited to its arboreal existence, mainly in the outer foliage. Specimens from this region are not sexually dichromatic like those on Banks Peninsula (green females, brown or grey males). Otago specimens are green with a series of white, fawn or yellow (usually black-edged) spots or continuous stripes dorsolaterally from the crown onto the tail. A series of similar spots runs from behind the eyes, along the sides and sometimes the full length of the tail. There is often a third series separating the light green sides from the pale yellowish-green or whitish belly colour.

Within the region the only substantiated records of *H. gemmeus* come from the Otago Peninsula (Fig. 5) where they occur in most of the remaining areas of forest or scrub. *H. gemmeus* is abundant in some very small, isolated remnant scrub patches (predominantly 2-4 m high divaricating species) which are open underneath, having been grazed right to the tree trunks. They can also be found in areas of stony pasture with scattered, isolated, divaricating, 1-2 m high bushes.

Heteropholis sp.. There are unsubstantiated reports of green geckos from several other areas within the region, although green geckos reported from Hindon and Waipori Gorge, a short distance inland from Dunedin, are probably *H. gemmeus.* In Fiordland National Park several people have reported green geckos from the Milford area, and near West Arm and Wilmot Pass. One was found in Francis Burn south of Lake Hauroko (Wood, Ms). Dumbleton (1947) recorded *Naultinus elegans (=Heteropholis* sp.?) from Invercargill as the host to type-specimens of the parasite *Trombicula naultini.* Several people have reported seeing green geckos on Bluff Hill and there is a second hand report of green geckos from Green I. in Foveaux Strait (L. Hazely, pers. comm). A *Heteropholis* specimen (SM E81.5), is reputedly from Stewart I., by the label on the jar. Green geckos also occur in tussockland at higher altitudes at Tara Hills and Hakataramea Pass only about 60 km north of this region and therefore probably occur further south.

Discussion:

Research is urgently needed for proper management and conservation of *H. rakiurae, L. otagense, L. acrinasum* and, in particular, *L. grande.*

Habitat modification can have a profound effect on lizard populations but introduced predators are also a major threat. Whitaker (1973) has shown conclusively that kiore *(Rattus exulans)* have been detrimental to lizards on northern New Zealand offshore islands, but there is little documentation of predation of lizards by other introduced rodents (Whitaker, 1978). Stack (1875) suggests that the arrival of cats and Norway rats *(Rattus norvegicus)* was a major reason for the disappearance of large species of lizards from North Canterbury. In the Central Otago habitats of *L. grande* and *L. otagense*, introduced cats *Felis catus*, stoats *Mustela erminea*, ferrets *Putorius putorius*, rats *Rattus sp.*, mice *Mus musculus* and hedgehogs *Erinaceus europaeus* are present, as well as natural predators (Australasian harrier, New Zealand falcon *Falco novaeseelandiae*, and kingfisher *Halcyon sancta)*. The extant populations of *L. grande* and *L. otagense* (including *'waimatense')* may therefore be relics of a formerly widespread distribution, and their apparently specialised habitats might be the only places in which these larger skinks have been able to survive, (Whitaker (1973) noted that the larger lizard species living in open habitats appeared more vulnerable to rodent predation). In recent years over-collection by enthusiastic pet-keepers has also had considerable impact on *L. otagense* populations (McDowall, 1978).

In Fiordland, *L. acrinasum* has been found only on islands that are apparently free of rats and wekas. *Rattus norvegicus* has been trapped on the central island of a group of three unnamed islands midway between Breaksea Is. and the Gilbert I. in Breaksea Sound. Here, no *L. acrinasum* were found during several searches of the rocky foreshore, but the two adjacent islands support populations of this skink. Nor were skinks found on rat-infested *(R. norvegicus)* Breaksea I. (Thomas, 1976) yet they occur on a small island nearby (Morrison, 1982). Similarly, in January 1981 skinks were found to be abundant on rock stacks less than 200 m offshore yet were absent from suitable habitat on the adjacent southern tip of Fivefingers Peninsula (although H. Cave (pers.comm.) in 1971 saw a skink *(L.acrinasum?)* on the seaward shoreline, midway along the Peninsula). Rat sign has been found elsewhere on Resolution I.

Rat and/or stoat sign was found on all of the Petrel Is. except for relatively isolated Entry I., which was the only one of the group to have skinks. Suitable islands for *L. acrinasum* in the Seal Is. group, at the entrance to Dusky Sound, have none and although rat sign was not found, wekas were present. These birds were observed foraging along the shoreline rocks and, as they are diurnal and have long beaks that can easily probe into the cracks and crevices, are probably more efficient than rats as predators of *L. acrinasum*.

Although wekas have dispersed to some inshore islands by swimming it is generally assumed that they were introduced by Maoris to many islands around Stewart I. (and possibly in Fiordland), in relatively recent times (Merton, 1978). The detrimental effect wekas have on some nesting seabird colonies (Wilson, 1959; Blackburn, 1968; and Merton, 1978) is considered so serious that costly eradication programmes are currently being undertaken by the New Zealand Wildlife Service, (e.g. on Codfish Island). On Green I., Foveaux Strait, a weka caught and ate a common gecko *(H. maculatus)* disturbed from under a sheet of corrugated iron, and gecko remains were found in the gut contents of another two wekas *(C & S.C.* pers. comm.).

In the Muttonbird Is. (Foveaux Strait), *H. granulatus* was found on Zero Rock, Womens I. and Herekopare I. which, except for cats on Herekopare, were free of introduced predators. However, on adjacent and rat-free Edwards I. where wekas are abundant no lizards were found (Adams and Cheyne 1969, and R.J. Nilsson, pers. comm.). Likewise, several islands in the Boat group have *H. granulatus* and *L. chloronoton*, but on Kundy I. which had wekas (but not rats) no lizards were found during concentrated searches of suitable habitats (R.J. Nilsson, pers. comm.). Recently 140 wekas were removed from this 22 ha island (R. Nilsson, pers. comm.), which indicates the very high density of wekas on some islands. This effect of wekas on lizards should receive research priority and be given consideration in any management proposals for these islands.

On Stewart I. *L. nigriplantare* is common and widespread despite heavy predation by cats (Thomas, 1981) and the presence of three species of rats. More information is needed to determine the status of *H. rakiurae* but remains of one of

these geckos have been found in a furball, regurgitated by a cat near the Robinson River (47° 8'15"S, 167°46'15"E) (B. Lloyd, pers. comm.). In the Southland Museum an old jar labelled "Stewart Island lizards" contained four *L. chloronoton,* three *H. maculatus,* a *H. granulatus and a Heteropholis* sp. However, no reference to this material could be found in the register so, without further information, the reputed origin of these specimens (recently designated SM E81.2-5) must remain in doubt — none of these species has been recorded from Stewart I. in recent years.

Many reportS of unidentified lizards in the region remain to be resolved, such as the green geckos in Fiordland and Southland, the possibly of *L. lineoocellatum* at Manuherikia, (Miller and Miller 1981), skinks in scree above the bushline in Jane Burn, Fiordland (K. Tustin, pers. comm.), a skink (unlikely to be *L. acrinasum)* in leaf litter under tall forest on the John Is. in Breaksea SOund (Morrison, 1982), and skinks on the Green Is., southern Fiordland (K. Morrison and R. Peacock, pers. comm.).

Acknowledgements

I thank the many individuals and Government Departments who supplied information and assistance; in particular A.H. Whitaker, R.P. Buckingham, D.A.R. Newman, P. Mainwaring, G.S. Hardy (National Museum), N. Hellyer, G. Loh, and R. Nilsson (N.Z. Wildlife Service), P. Gay (Southland Education Board), L. Hazely (Southland Museum), several Fiordland National Park staff and colleagues in Ecology Division of D.S.I.R.

References

ADAMS, J.S. and J.W. Cheyne 1969: Titi Islands (Mutton bird) survey, December 1968. Unpublished File Report (46/33/138) New Zealand Wildlife Service, Department of Internal Affairs, Wellington. 13 pp.

ANON, 1980: *Lake Alexandrina Study 1980. A Public Discussion Document on Recreation, Accommodation and Development.* Department of Lands and Survey (Christchurch), Town and Country Planning Division of Ministry of Works and Development (Christchurch), McKenzie County Council (Fairlie) and South Canterbury Acclimatistion Society (Timaru). 115pp.

BLACKBURN, A. 1968: The birdlife of Codfish Island. *Notornis 15: 51-65.*

BULL, P.C. and A.H. WHITAKER 1975: The amphibians, reptiles, birds and mammals. Pp. 231-276 in G. Kuschel (Ed.) *Biogeography and Ecology in New Zealand.* Junk, The Hague.

CROOK, I.G. 1975: The tuatara. Pp. 331-352 in G. Kuschel (Ed.) *Biogeography and Ecology in New Zealand.* Junk, The Hague.

DUMBLETON, L.J. 1947: Trombidiidae (Acarina) from the Solomon Islands and New Zealand. *Transactions of the Royal Society of N.Z.* 76 (3): 409-413.

HARDY, G.S. 1977: The New Zealand Scincidae (Reptilia: Lacertilia); a taxonomic and zoogeographic study. *N.Z. Journal of Zoology 4:* 221-325.

HARDY, G.S. and A.H. WHITAKER 1979: The status of New Zealand's reptiles and their conservation. *Forest and Bird 13(4):* 34-39.

MAINWARING, J. 1979: Feeding habits of giant Otago skinks. *Moko* 79/3: 4-5.

McCANN, C. 1955: The lizards of New Zealand. Gekkonidae and Scincidae. *Dominion Museum Bulletin No. 17.*

McDOWALL, R. 1978: On the trail of Otago giants. Moko, December: 2-3.

MARTIN, W. 1929: *The New Zealand Nature Book.* Vol. 1. The Fauna. Whitcombe & Tombs, Auckland.

MERTON, D.V. 1978: Controlling introduced predators and competitors on islands. Pp. 121-128 in S.A. Temple (Ed). *Endangered Birds; Management Techniques for Preserving Threatened Species.* University of Wisconsin Press, Madison.

MIERS, K.H. 1963: Report of visit to Takahe Valley February 1963. Unpublished File Report (49/1) Department of Lands and Survey, Invercargill. 2 pp.

MILLER, P.J. and K.F. MILLER (1981): The Lizards of Otago, South Island, New Zealand. Unpublished Report to the N.Z. Wildlife Service, Department of Internal Affairs, Dunedin. 13 pp.

MORRISON, K. 1982: Report on a visit to Islands in Breaksea and Dusky Sounds, October 1981. Unpublished File Report (FNP 28/2). Department of Lands and Survey, Invercargill.

ROBB, J. 1980: *New Zealand Amphibians and Reptiles in Colour.* Collins, Auckland.
ROBB, J. and R.P.V. ROWLANDS 1977: Reinstatement of *Hoplodactylus maculatus* (Boulenger) with redescription of *H. pacificus* (Gray). (Reptilia: Squamata: Gekkonidae). *Records of the Auckland Insitute and Museum 14: 133-142.*
STACK, J.W. 1875: On the disappearance of the larger kinds of lizard from North Canterbury. *Transactions of the New Zealand Institute 7:* 295-297.
THOMAS, B.W. 1976: Report on visit to Breaksea Island, the 'Seal Islands' and the Gilbert Islands, Fiordland, December 1974. Unpublished File Report held in library of Ecology Division, Department of Scientific and Industrial Research, Lower Hutt, N.Z. 24 pp.
THOMAS, B.W. 1977: Preliminary survey of a skink population *(Leiolopisma grande)* in the upper Wairau River, April 1977. Unpublished File Report held on Ecology Division file 7/1/1 Department of Scientific and Industrial Research, Lower Hutt, N.Z. 4 pp.
THOMAS, B.W. 1981: *Hoplodactylus rakiurae* n. sp. (Reptilia: Gekkonidae) from Stewart Island, New Zealand, and comments on the taxonomic status of *Heteropholis nebulosus* McCann. *N.Z. Journal of Zoology 8:* 33-47.
THOMAS, B.W. (in press): New Zealand Gekkonidae — evolutionary trends and taxa. In D.G. Newman (Ed.), *New Zealand Herpetology: Proceedings of a Symposium held 29-31 January 1980.* N.Z. Wildlife Service, Department of Internal Affairs, Wellington.
WHITAKER, A.H. 1973: Lizard populations with and without Polynesian Rats, *Rattus exulans* (Peale). *Proceedings of the New Zealand Ecological Society* 20: 121-130.
WHITAKER, A.H. 1978: The effects of rodents on reptiles and amphibians. Pp. 75-88 in I.A.E. Atkinson, P.R. Dingwall & C. Hoy (Eds.), *The Ecology and Control of Rodents in New Zealand Nature Reserves.* N.Z. Department of Lands and Survey, information Series 4.
WHITAKER, A.H. (in press): Interim results from a study of *Hoplodactylus maculatus* (Boulenger) at Turakirae Head, Wellington. In D.G. Newman (Ed.), *New Zealand Herpetology: Proceedings of a Symposium held 29-31 January 1980.* N.Z. Wildlife Service, Department of Internal Affairs, Wellington.
WILLIAMS, G.R. and D.R. GIVEN 1981: *The Red Data Book of New Zealand.* Nature Conservation Council, Wellington.
WILSON, R.A. 1959: *Bird Islands of New Zealand.* Whitcomb and Tombs, Christchurch.
WOOD, B.L. (Ms. — field notebook): A visit to the Tewaewae Bay area, Foveaux Strait, 14-22 November 1948, 6 January to 5 February 1949. Held at New Zealand Geological Survey, Department of Scientific and Industrial Research, Dunedin, New Zealand.

NOTE ADDED IN PRESS

Two skinks, recently collected by the New Zealand Wildlife Service Fauna Survey Unit, from Lake Onslow and Falls Dam, Manuherikia, are in my opinion *Leiolopisma chloronoton.* This confirms a more northern distribution for *L. chloronoton* than shown in Fig. 2B and gives some credibility to the Otago Museum specimen (A98.77) reputedly from Timaru. I now consider that skinks from Manuherikia, previously identified from photographs as *L. lineoocellatum* (p. 13), are *L. chloronoton.*

Also, the Fauna Survey Unit have found *L. grande* and *L. otagense* form *otagense* as far north as the Lindis Valley and Lake Hawea areas, which considerably extends the known range for these species.

REPTILES OF THE HAURAKI GULF, NEW ZEALAND

J. McCallum. Department of Zoology,
University of Auckland, Private Bag,
Auckland 1. New Zealand.

Abstract

The islands of the Hauraki Gulf are noted for their diverse reptile fauna. Sixteen of the thirty-eight currently recognized species of New Zealand reptiles are to be found in this region. This is attributed to the large number of islands, the isolation of the outer groups and the fact that many are predator-free.

Introduction

The islands considered most noteworthy for their reptile faunas stretch from the northern Poor Knights to the Aldermen Group in the south. Many are included within the Hauraki Gulf Maritime Park and access to some is by permit only. Islands mentioned in this survey are shown in Fig. 1.

The majority of islands close to shore have been extensively modified by man with farming, the erection of buildings and the introduction of mammallian predators. Their impoverished reptile fauna, in general, is similar to that of the mainland.

The species found within the Hauraki Gulf are listed in Table 1. A more complete distribution is given by the authors listed in the Bibliography.

Table 1.

Order Rhynchocephalia	*Sphenodon punctatus* (tuatara)
Order Squamata	
Family Gekkonidae	*Hoplodactylus duvauceli*
	H. granulatus
	H. maculatus
	H. pacificus
	Naultinus elegans
Family Scincidae	*Cyclodina aenea*
	C. alani
	C. macgregori
	C. oliveri
	C. ornata
	C. whitakeri
	Leiolopisma homalonotum
	L. moco
	L. smithi
	L. suteri

THE ISLANDS

Poor Knights

Due to their size (230 ha), lack of introduced predators, and their isolation (26 km from the mainland), the Poor Knights have a spectacular fauna and flora. The reptiles present are tuataras, *H. duvauceli, H. pacificus, C. aenea, C. oliveri, C. ornata, L. moco, L. smithi* and *L. suteri.*

The Poor Knights consist of two large and three smaller islands and a number of stacks. Two of the latter, lying to the south-west of the main group, contain populations of *H. pacificus* and *L. smithi*, despite lack of vegetation. Fish scraps brought ashore by nesting gannets may be an important seasonal food supply to these lizards.

Five species of seabirds (Buller's shearwater, fluttering shearwater, allied shearwater, fairy prion and diving petrel) are common seasonal breeders. Crook-

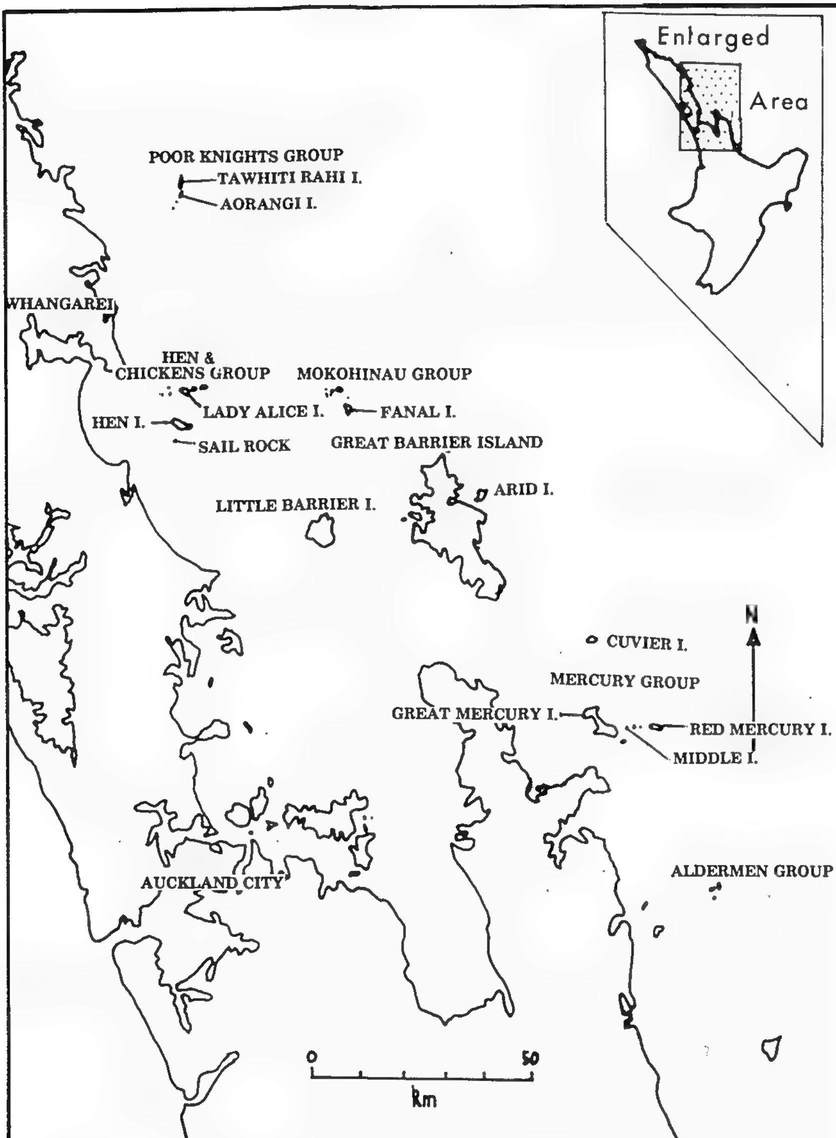


Figure 1. The Hauraki Gulf, showing location of islands mentioned in the text.

(1974) has discussed the benefit that seabirds may impart on tuataras, which includes soil friability, transport of nutrients ashore, formation of burrows and even acting as a prey source.

Mokohinau Islands

This volcanic group consists of 25 islands and stacks 105 km north-east of Auckland City. Most of the larger islands are kiore (*Rattus exulans*) — inhabited and have corresponding depauperate lizard faunas. Tuataras were present on several islands until the 1930s, but are now locally extinct, presumably due to the effects of collecting, burning off of the islands by mutton-birders and predation by rats. Lizards present include *H. duvauceli, H. pacificus, C. ornata, C. aenea, C. oliveri, L. moco, L. smithi* and *L. suteri.*

Hens & Chickens Islands

Hen Island (520 ha) lies 6 km south of the five Chicken Islands. Kiore are present on the larger islands, causing species to become restricted to protected habitats (e.g. boulder beaches or cliffs for *H. duvauceli*) or rat-free stacks for *H. pacificus, H. maculatus* and *C. oliveri. C. macgregori,* which is known from only three islands in New Zealand, occurs on rat-free Sail Rock (2 ha), several km south of Hen Island. Other species present in the group are *C. aenea, C. ornata, L. moco, L. smithi, L. suteri* and tuataras.

Little Barrier Island

Little Barrier (2817 ha) is the main stronghold of the stitchbird and Cook's petrel and is an important bird sanctuary. Kiore are numerous and feral cats were present until their removal in 1979. *C. oliveri* is found in an extensive boulder bank which is inaccessable to kiore, explaining the co-existence of two incompatible species. Tuataras were last seen in the mid-1970s and are now presumed locally-extinct. Other species present are *H. duvauceli, H. granulatus, H. pacificus, N. elegans, C. aenea, C. ornata, L. moco, L. smithi* and *L. suteri.*

Great Barrier Island

Great Barrier (28,500 ha) has 12 lizard species, despite the presence of mice, rats, cats, feral pigs and a substantial human occupancy. However, many of the lizards are rare. The fauna consists of *H. duvauceli* (may be locally extinct), *H. granulatus, H. maculatus, H. pacificus, N. elegans, C. aenea, C. oliveri, C. ornata, L. homalonotum, L. moco, L. smithi* and *L. suteri.* The native frog, *Leiopelma hochstetteri,* is also present.

Hardy (1977) has suggested that the range of *L. homalonotum* "is but a fraction of its former extent". It is possible that its range was once more extensive, having been reduced by either predation and/or habitat disturbance. It only occurs on Great Barrier Island, co-existing with introduced predators in habitats which were selectively milled earlier this century. (Therefore, it may not be so sensitive to disturbance as to influence its distribution to "predator-free islands".) It may be speculated that *L. homalonotum* is endemic to Great Barrier Island. Its habitat, consisting of log debris in stream beds, offers some degree of protection from predation.

Arid Island

Arid Island (300 ha) lies 3 km off the north-east coast of Great Barrier Island. Ship rats *(Rattus rattus)* and wekas *(Gallirallus australis)* are the only introduced predators to the island, but the lizard fauna is poor and consists of *H. pacificus, H. maculatus, C. aenea, C. ornata* and *L. moco*, all in low numbers.

Cuvier Island

Cuvier (180 ha) is located 25 km south-east of Great Barrier and is the site of a manned lighthouse station. Feral goats and cats were removed in the early 1960s, but kiore are abundant. It is noted for its population of the rare bird, the North Island saddleback. *H. pacificus, H. maculatus, C. aenea, L. moco, L. smithi* and *L. suteri* occur on the island and several tuataras have also been located.

Scott's Monument, a small offshore rat-free stack, has a dense population of *H. maculatus.* Allopatric distributions of *H. pacificus* and *H. maculatus*, on small off-shore stacks (less than 1 ha), for example Scott's Monument, suggest that mechanisms such as niche competition may result in the exclusion of one or the other species.

Mercury Group

The Mercuries consist of seven major islands and a number of smaller stacks. The largest island is Great Mercury (1,800 ha). Middle Island of this group is noted for the occurrence of *C. alani* and *C. whitakeri,* the latter being one of the rarer and least-known of the New Zealand lizards. A variety of other reptilian species occur, including the tuatara, *H. duvauceli, H. maculatus, H. pacificus, L. moco, L. smithi, L. suteri, C. aenea* and *C. oliveri.*

Last century, Great Mercury was inhabited by a large population of gumdiggers and is now farmed. It has been much modified resulting in a low density lizard fauna. Red Mercury (220 ha) also has a depauperate fauna; no species are abundant and the tuatara is rarely seen. This may be attributed to a long occupancy by kiore.

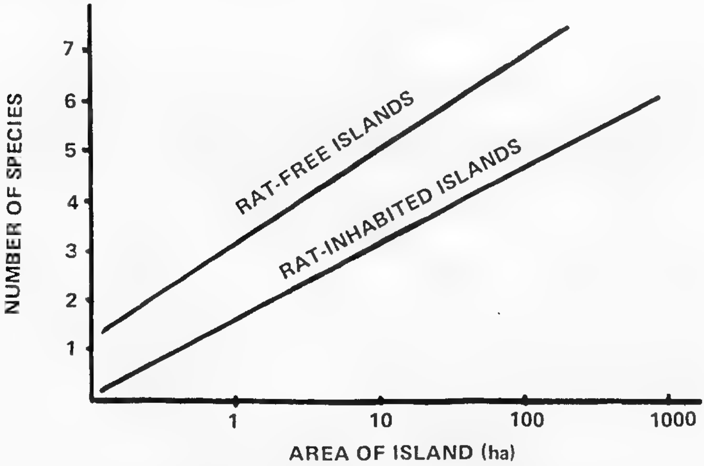


Figure 2. (After Whitaker 1978). The relationship between the number of lizard species, island size and the presence of kiore.

Aldermen Group

The southern-most group within the Hauraki Gulf Maritime Park, the Aldermens comprise six major islands and a number of small stacks, totalling 90 ha. Only one island in the group is inhabited by kiore, the rest are predator-free and have rich faunas.

The tuatara occurs in abundance on six of the islands; other species include *H. duvauceli, H. maculatus, H. pacificus, C. oliveri, C. aenea, L. smithi, L. moco* and *L. suteri.*

Discussion

Current taxonomists do not recognise any reptiles endemic to a particular island group within the Hauraki Gulf, apart from the possibility of *L. homalonotum* on Great Barrier Island. This may be attributed to the Pliocene-

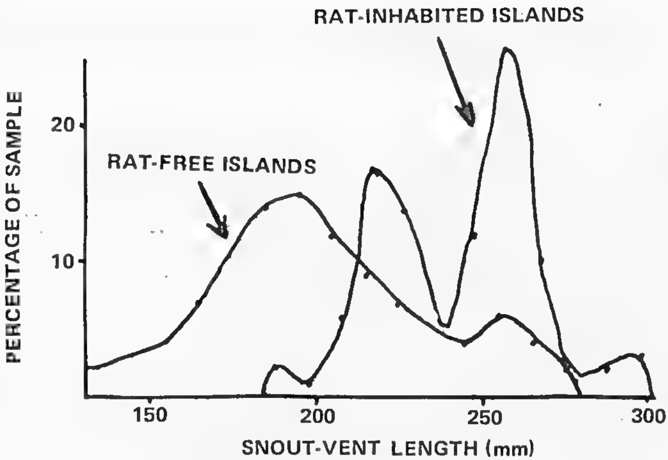


Figure 3 (After Crook 1973a). Comparison of snout-vent lengths of tuataras on kiore-free and kiore-inhabited islands.

Pleistocene glaciations, when all these islands were connected to the mainland and the subsequent isolation has not been of sufficient duration to result in speciation.

The effect of kiore modification on an island ecosystem may be through predation and/or competition. The larger geckos and skinks, especially *H. duvauceli, C. alani, C. macgregori, C. oliveri* and *C. whitakeri* are severely restricted or entirely absent on rat-inhabited islands.

Whitaker (1973, 1978) has discussed the impact of rats on lizard populations in detail.

Many of the New Zealand reptiles are vunerable to rat predation, since they have evolved in the absence of mammalian predators.

Crook (1973a) has shown that the recruitment of young tuataras into the adult population will be severely retarded by the presence of kiore. The kiore is assumed to have reached the New Zealand mainland with the arrival of the polynesians about 1000 AD. The subsequent spread of this rat to the offshore islands has resulted in island systems in various stages of modification e.g. Hen Island, with few tuataras, may have been inhabited by kiore for a longer period than the nearby Chicken Islands, where young tuataras can be found in the presence of kiore.

The larger skinks, especially *C. alani, C. macgregori, C. oliveri* and *C. whitakeri* are thought to have once ranged over much of the North Island (Whitaker 1978). Access to the offshore islands, such as those of the Hauraki Gulf, would have been gained during glacial periods when the sea level was at least a hundred metres lower than at present. Over the last thousand years, the effect of introduced predators has most probably resulted in localised extinctions of these larger skinks. The most significant predator is the kiore; European introductions faced an already modified environment. Consequently, these skinks have relictual distributions on some of the few remaining rat-free islands.

The importance of maintaining predator-free islands cannot be over-stressed. Vermin, especially ship rats *(Rattus rattus)* can easily reach small islands from

boats. Furthermore, the Hauraki Gulf is becoming increasingly popular for boating and many illegal landings occur on flora and fauna sanctuaries. It is only through public awareness than the wildlife value of these islands will be maintained.

Bibliography

ATKINSON, I.A.E. 1964: The flora, vegetation and soils of Middle and Green Islands, Mercury Islands group. *N.Z Journal of Botany 2:* 385-402.

ATKINSON, I.A.E. 1972: Vegetation and flora of Sail Rock, Hen and Chicken Islands. *N.Z. Journal of Botany 10:* 545-558.

BOULENGER, G.A. 1906: Descriptions of two new lizards from New Zealand. *Annuls & Magazine of Natural History (7)17:* 369-371.

BULL, P.C. & A.H. WHITAKER 1975: The amphibians, reptiles, birds, and mammals. Pp. 231-276 *in* Kuschel, G. (Ed.), Biography and Ecology in New Zealand. Junk, the Hague.

BULLER, W.L. 1876: Notes on the tuatara lizard *(Sphenodon punctatum),* with a description of a supposed new species. *(Trans. and Proc. of the N.Z. Inst. 9:* 317-325.

CROOK, I.G. 1970: The tuatara. Wildlife — a review 1970: 16-19

CROOK, I.G. 1973a: The tuatara, *Sphenodon punctatus* Gray, on islands with and without populations of the Polynesian rat, *Rattus exulans* (Peale). *Proc. of the N.Z. Ecol. Soc. 20:* 115-120.

CROOK, I.G. 1973b: Tuatara and the Polynesian rat. Wildlife — a review 1973: 47-48.

CROOK, I.G. 1974: Are tuataras dependent on petrels? Wildlife — a review 1974: 43-46.

CROOK, I.G. 1975: The tuatara. Pp. 331-352 *in* Kuschel, G. (Ed.), Biography and Ecology in New Zealand. Junk, The Hague.

DICK, B.B. 1981: A lizard study on Great Barrier Island. *Herpetofauna 12(2):* 3-5.

FALLA, R.A. 1960: The fauna of New Zealand, New Zealand reptiles. *In* McClintock, A.H. (Ed.), A Descriptive Atlas of New Zealand. R.E Owen, Govt. Printer, Wellington.

FAWCETT, J.D. 1971: Note on the occurrence of the black shore skink, *Leiolopisma suteri,* Port Jackson, North Island, New Zealand. *N.Z. Jour. Sc. 14(4):* 1112-1114.

HAMILTON, W.M. 1961 (Ed.): Little Barrier Island (Hauturu). *N.Z. Dept. of Scientific and Industrial Research Bull. 137.*

HARD, G.C. 1954: Notes on reptilia of islands visited by Field Club. *Tane 6:* 143-146.

HARDY, G.S. 1977: The New Zealand Scincidae (Reptilia: Lacertilia); a taxonomic and zoogeographic study. *N.Z Jour. Zoo. 4:* 221-325.

HARDY, G.S. & A.H. WHITAKER 1979: The status of New Zealand's endemic reptiles and their conservation. *Forest & Bird 13(4):* 34-39.

HICKS, G.R.F.; H.P. McCOLL, M.J. MEADS, G.S. HARDY & R.J. ROSER 1975: An ecological reconnaissance of Korapuki Island, Mercury Islands. *Notornis 22:* 195-220.

HITCHMOUGH, R.A. & J. McCALLUM 1982: Lizards of Rakitu (Arid) Island. *Tane 28*: 135-136.

HUTTON, F.W. & J. DRUMMOND 1904: The Animals of New Zealand. An Account of the Colony's Air-breathing Vertebrates. Whitcombe & Tombs, Christchurch.

McCALLUM, J. 1980: Reptiles of the northern Mokohinau Group. *Tane 26:* 53-59.

McCALLUM, J. 1981: Reptiles of Tawhiti Rahi Island, Poor Knights Islands, New Zealand. *Tane 27*: 55-58.

McCALLUM, J & F.R. HARKER 1981: Reptiles of Cuvier Island. *Tane 27*: 17-22.

McCANN, C.M. 1955: The lizards of New Zealand. *Dominion Museum Bull. 17.*

NEWMAN, D.G. 1980: Herpetological symposium. Wildlife — a review 1980: 39-47.

OGLE, C.C. 1981: Great Barrier Island Wildlife Survey. *Tane 27.*
REISCHEK, A. 1885: Observations on *Sphenodon punctatum,* fringe-back lizard (tuatara). *Trans. & Proc. N.Z. Inst. 18:* 108-110.
ROBB, J. 1970: A new skink of the genus *Leiolopisma* from New Zealand. *Proceedings of the Section of Sciences, Koninklijke Nederlandse Akademie van Wetenschappen, Series C73(2):* 228-229.
ROBB, J. 1973: Reptiles and amphibia. Pp. 285-303 *in* Williams, G.R. (Ed.), The Natural History of New Zealand. Reed, Wellington.
ROBB, J. 1975: Two new skinks of the genus *Leiologisma* from New Zealand. *Proceedings of the Section of Sciences, Koninklijke Nederlandse Akademie van Wetenschappen, Series C78(5):* 477-484.
ROBB, J. 1977: A revision of the synonymy of three species of leiolopismid skinks from New Zealand. *Bull. of the British Museum of Natural History (Zoology) 31(6):* 303-310.
ROBB, J. 1980: New Zealand Amphibians and Reptiles in Colour. Collins, Auckland.
ROBB, J. & R.A. HITCHMOUGH 1980: Review of the genus *Naultinus* Gray (Reptilia: Gekkonidae). *Records of the Auckland Institute and Museum 16:* 189-200.
ROBB, J. & R.P.V. ROWLANDS 1977: Reinstatement of *Hoplodactylus maculatus* (Boulenger) with redescription of *H. pacificus* (Gray) (Reptilia: Squamata: Gekkonidae). *Records of the Auckland Institute and Museum 14:* 133-142.
PORTER, R. 1981: Lizards of Lady Alice Island, Hen and Chickens Group, North-east New Zealand. *Herpetofauna 13(1):* 26-28.
SHARELL, R. 1966: The Tuatara, Lizards and Frogs of New Zealand. Collins, London.
SLADDEN, B. & R.A. FALLA 1928: Aldermen Islands. A general description, with notes on the flora and fauna. *N.Z Journal of Science & Technology 9(5):* 282-290.
TOWNS, D.R. 1971: The lizards of the islands visited by Field Club 1953-54. A revision with some additions 1969-1970. *Tane 17:* 91-96.
TOWNS, D.R. 1972: The reptiles of Red Mercury Island. *Tane 18:* 95-105.
TOWNS, D.R. 1974: A note on the lizards of the Slipper Island Group. *Tane 20:* 35-36.
TOWNS, D.R. 1975a: Ecology of the black shore skink, *Leiolopisma suteri* (Lacertilia: Scincidae), in boulder beach habitats. *N.Z. Journal of Zoology 2(4):* 389-407.
TOWNS, D.R. 1975b: Reproduction and growth of the black shore skink, *Leiolopisma suteri* (Lacertilia: Scincidae) in north-eastern New Zealand. *N.Z. Journal of Zoology 2(4):* 409-423.
TOWNS, D.R. & B.W. HAYWARD 1973: Reptiles of the Alderman Islands. *Tane 19:* 93-102.
WEST, J.A. 1979: Range extension for *Leiolopisma homalonotum* (Boulenger). (Short note). *Herpetofauna 10(2):* 31.
WHITAKER, A.H. 1968a: *Leiolopisma suteri* (Boulenger), an oviparous skink in New Zealand. *N.Z. Journal of Science 11(3):* 425-432.
WHITAKER, A.H. 1968b: The lizards of the Poor Knights Islands, New Zealand. *N.Z. Journal of Science 11(4):* 623-651.
WHITAKER, A.H. 1973: Lizard populations on islands with and without Polynesian rats, *Rattus exulans* (Peale). *Proc. of the N.Z. Ecological Soc. 20:* 121-130.
WHITAKER, A.H. 1978: The effects of rodents on reptiles and amphibians. *In* Dingwall, P.R.; Atkinson, I.A.E. & Hay, C. (Eds.) The ecology and control of rodents in New Zealand nature reserves. *Dept. of Lands and Survey Information Series No. 4:* 75-88.

NEW ZEALAND HERPETOLOGICAL RESEARCH — THE WORK OF THE NZ WILDLIFE SERVICE

Donald G. Newman
Wildlife Service, Department of Internal Affairs,
Private Bag, Wellington, N.Z.

Summary

Herpetological research carried out by the New Zealand Wildlife Service is described. Results of completed work are summarised and the aims of current projects outlined. A plea is made for other organisations, and individuals, to contribute towards the research necessary to conserve New Zealand's herpetofauna.

The Wildlife Act of 1953 is the legal basis upon which the work of the New Zealand Wildlife Service is founded. One of the main purposes of the Act is to bestow absolute protection upon most native vertebrate species. With regard to herpetofauna, the tuatara, *Sphenodon punctatus,* and the three species of native frog, *Leiopelma hochstetteri, L. archeyi* and *L. hamiltoni,* are fully protected, and in 1981 an Order in Council was made (the Wildlife Order 1981) giving protection to all but four New Zealand lizards. The four species exempted from protection (common gecko *Hoplodactylus maculatus,* forest gecko *H. granulatus,* common or McCann's skink *Leiolopisma nigriplantare maccanni,* and copper skink *Cyclodina aenea)* are our most common and widely distributed ones. The legislation to protect lizards was delayed by the difficulty of resolving New Zealand lizard taxonomy. Over recent years, however, much progress has been made (Hardy 1977, Hardy and Hicks 1980, Robb and Rowlands 1977, Robb and Hitchmough 1980, Robb 1980a, b, Thomas 1981) even though some points require further rationalisation.

The Wildlife Act 1953 brought up to date and replaced legislation known as the Animals Protection and Game Act 1921-22. This earlier Act, in its turn, replaced previous statutes. In fact, the first item of legislation specifically dealing with New Zealand wildlife, promulgated in 1861, was the Protection of Certain Animals Act, which made no mention of native species whatsoever. The unique status of the tuatara, as the world's sole surviving rhynchocephalian, was instrumental in

Figure 1 The tuatara, *Sphenodon punctatus,* the world's sole surviving rhynchocephalian.

its becoming one of the first native species to receive full legal protection. A warrant dated 1 April 1895, published in the New Zealand Gazette 4 April 1895, gave absolute protection to the "tuatara lizard". A further warrant, published 2 September 1898, bestowed full protection on the "tuatara lizard and their eggs". Native frogs have been given strict legal protection since 1922, initially under the Animals Protection and Game Act 1921-22.

Today, the Wildlife Service is basically scientifically orientated and relies upon ecological research for guidance in almost all of its management policies. The Service's first scientist to work on the tuatara, Ian Crook, was appointed in November 1969. Before this time, however, the Service kept in close contact with, and received management advice from Dr William Dawbin who commenced a long-term study of the life history, growth and longevity of the tuatara on Stephens Island, 40°40'S 174°00'E, in 1949 (Dawbin 1949, 1962, 1982). This study is still progressing. Dr Dawbin has discovered that the growing period of the tuatara is approximately 60 years and sexual maturity is attained at about 20 years. As a consequence, he believes that the life expectancy of the rhynchocephalian is likely to exceed 100 years (Dawbin 1962, 1982).

Ian Crook set about defining the tuatara's relationship with key features of its environment, such as burrow-nesting petrels and shearwaters of the families Hydrobatidae, Procellariidae and Pelecanoididae, and the Polynesian rat or kiore, *Rattus exulans*. Firstly, detailed knowledge of the tuatara's distribution was sought, and the "status" of each of the reptile's island populations determined. Information was gathered on whether or not tuataras were breeding on each of the islands where they occurred, and features of the tuataras' environment which might influence their breeding success were noted. During the ensuing survey, young tuataras were rarely encountered on kiore-inhabited islands. Tuataras found co-existing with the rats were almost all greater than 200mm snout-vent length (Crook 1973 a, b). No kiore-inhabited island was found which also supported a clearly self-maintaining population of tuataras, which strongly suggests that the reptiles cannot persist in the presence of this rat (Crook 1973a, b, 1975). It also became apparent that the introduction of rats may not be the sole factor accounting for the tuatara's current distribution as the rat-free Hongiora Island, in

Figure 2 The Polynesian rat, or kiore, *Rattus exulans.*

The Aldermen group, 36°58'S 176°05'E, was found to support only a very small population of aged tuataras (Crook 1973a, b, 1975).

Most tuatara islands support several species of petrels and shearwaters. However, the islands were tuataras are definitely maintaining their numbers have very large breeding populations of either or both the fairy prion, *Pachyptila turtur*, and the diving petrel, *Pelecanoides urinatrix*, the two smallest, widely distributed petrels in the tuatara's range (Crook 1974b, 1975). Undoubtedly, the birds provide tuataras with many benefits, principally in the way of housing and food. They excavate the burrows within which many tuataras live (though the reptiles can and do dig their own), and by turning over and incorporating into the soil their mineral rich guano, create conditions that may encourage ground-dwelling invertebrates which form the bulk of the tuatara's diet (Crook 1974b, 1975, Dawbin 1962).

The coincidence of tuataras and petrels led Ian Crook to consider whether the tuataras were dependent on petrels for their survival. While recognising that the survival of both was linked with the absence of rats, he attempted to determine whether their patterns of occurrence on one island (Stephens Island) were dependent or independent of one another. He looked closely at the relative numbers of tuataras and fairy prions (fairy prions are the most abundant petrel species nesting on Stephens Island) on different parts of the island (Crook 1970b) and found that a relationship did exist between the distribution of the two species. He discovered that the density of tuataras varies with the density of fairy prions and their burrows. This, in turn, is influenced by soil type and soil compaction by sheep and cattle. Although the relationship is not a simple one, it can be generally stated that tuataras are more plentiful in areas supporting moderate, rather than low or high prion numbers, and they seem to prefer living on the periphery of dense prion populations (Crook 1974b, 1975). These findings gave no proof of dependence but further emphasised the close ecological relationship that occurs between the birds and the reptiles and encouraged further research, particularly closer studies of the relationship between tuataras and petrels in burrows.

Figure 3 The fairy prion, *Pachyptila turtur*.

In November 1970, Tony Whitaker and Bruce Thomas, Ecology Division, D.S.I.R., accompanied Ian Crook on one of his visits to Stephens Island. Tony and Bruce had as their objectives the recording and assessing of the status of lizards on the island. While searching the top of the island at night they found three Hamilton's frogs, *Leiopelma hamiltoni* — the first Hamilton's frogs seen on Stephens Island since 1962. The frogs were discovered climbing in thick grass and *Muehlenbeckia* vines near the edge of a small lichen-covered rock tumble (Crook 1970a, Crook *et al.* 1971). This small rock tumble ($600m^2$) — often referred to as the "frog bank" — is one of the two known habitats of this species. Tony and Bruce's find was of significance since all but one of the frog observations prior to 1970 were made by excavation on the bank (surface activity was first recorded by Dr Dawbin in 1954 — Dawbin pers. comm.). Observations of the frog had, in fact, been made at very infrequent intervals and the suggestion had been made that *L. hamiltoni* was, or was likely to become, extinct on Stephens Island (see Stephenson and Stephenson 1957). Further sightings revealed that given suitable weather conditions — damp nights with moderate temperatures (Newman 1977a) — frogs could be readily detected on the surface of the bank. Intensive study of the population was therefore feasible.

Hamilton's frog is the rarest of New Zealand's three native frogs and may be one of the rarest frogs in the world (Bull and Whitaker 1975). Apart from Stephens Island, it has only been found on Maud Island, 41°02'S 173°53'E, in Pelorus Sound. On Maud Island it is confined to 15 hectares of remnant forest. The extreme rarity of this species led to an investigation of ways of increasing its distribution. As a start it is hoped that additional habitats can be created on both Stephens and Maud Islands. In order to create additional habitats, as much as possible had to be determined about the frog and its ecological requirements. A start was made by studying and comparing the frog's existing habitats, paying special attention to climate (Crook 1974a). Later the frog populations were examined, at first the small Stephens Island population and, more recently, selected parts of the much larger Maud Island population. The ground in both habitats is covered by rocks, but while on Maud Island the habitat is sheltered by tall forest, on Stephens Island the forest that once covered the frog bank was destroyed by cattle and sheep about 50 years ago (Crook 1970a, Crook *et al.* 1971, Newman 1977b, 1982a, Newman *et al.* 1978). In both areas the frogs, which require a moist environment, spend most of their time in crevices between and under rocks. A comparative study of the climates of the habitats showed that conditions under the rocks are much cooler and more humid than those on the surface (Newman *et al.* 1978). Our studies, in fact, have suggested that the frog was able to survive the deforestation of its Stephens Island habitat and the consequent drier surface conditions by taking advantage of very deep refuges in rock crevices. Crevices also offer frogs protection from predators. This is important as there is now some evidence that tuataras may eat Hamilton's frogs (Newman 1977a).

On Stephens Island the ideal place to create the first additional habitat would appear to be in a small forest remnant 100 metres from the frog bank. We know that the climate is suitable for frogs (Newman 1982a); all that is lacking is adequate shelter from seasonally dry conditions and from tuataras. This shelter could be provided by excavating a large pit and filling it with rocks (Newman 1977a, b, 1982a). After checking that conditions at the base of this pit remain moist during dry periods and that sufficient food (small invertebrates) is available, 10 frogs, taken from the frog bank, could be introduced. It is considered that at least 10 frogs (5 pairs) would be necessary to start a new colony.

Study of the Stephens Island frog population, started in February 1975, was aimed at obtaining an accurate estimate of its size in order to evaluate the number that could safely be removed. Because of the small size of the habitat and the presumed low number of frogs, great care was taken to use sampling

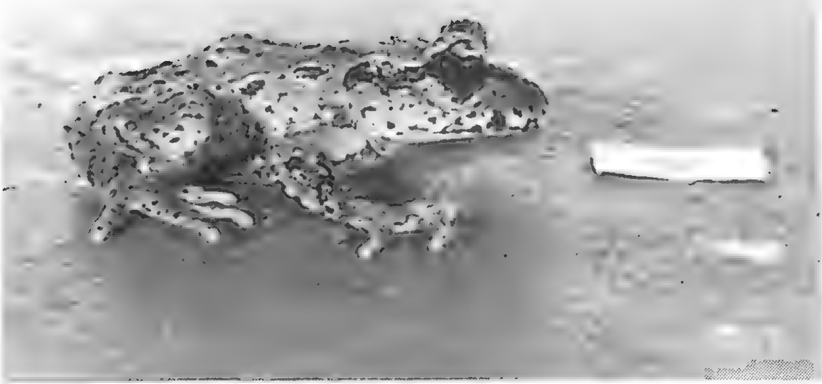
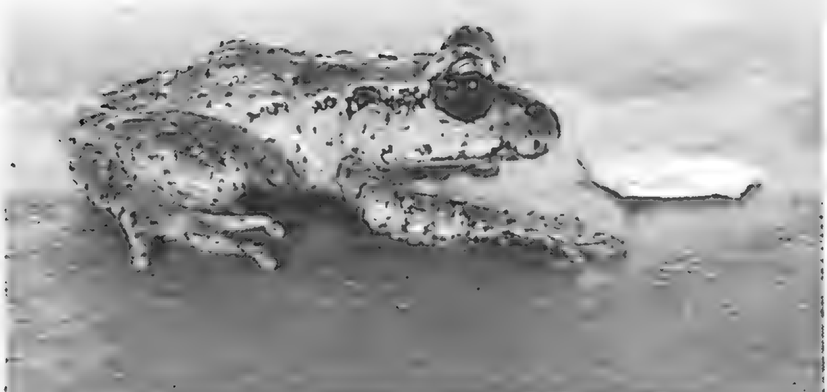


Figure 4 Two Hamilton's frogs, *Leiopelma hamiltoni*, from Stephens Island. Note the difference in their skin colour patterns particularly along their upper lips.



techniques that caused as little disturbance as possible. Sampling was confined to nights and only those animals seen on the surface were recorded. To reduce the risk of accidentally stepping on frogs, a special "walkway" was constructed.

During each sampling, an area approximately one metre wide on either side of the walkway was searched, as well as those areas of rocks not covered by vegetation. Any frogs discovered were captured, taken to a nearby hide where they were weighed, measured and photographed. They were afterwards returned to their location of capture. Photographic records allowed the distinguishing of individuals. Each frog has a unique skin colour pattern from which it can be readily recognised, in particular by the series of black markings along the upper lip.

By using these techniques I have estimated that the Stephens Island habitat supports at least 200 frogs, 10-15 of which could probably be removed without hazard to start a new colony (Newman 1982a). If we can successfully establish frogs in a newly created habitat on Stephens Island, by using similar methods we could later transfer them to other islands and even, perhaps, to the mainland.

Ian Crook's investigation of tuatara-fairy prion relationships on Stephens Island (Crook 1974b, 1975) indicated that closer studies of the two species, in burrows, could be most worthwhile. Such a study was undertaken by Geoff Walls, a Wildlife Scholar, as part of his broader research programme to obtain information on the ecology of the tuatara on Stephens Island — including feeding ecology (Walls 1981) and surface activity. By observing animals in 50 specially prepared study burrows during 1974-75, Geoff was able to ascertain that tuataras were directly responsible for the loss of more than one quarter of the eggs and chicks of fairy prions, by predation and interference in the birds' nesting chambers (Walls 1978). He considered that this mortality was not a major factor in the regulation of the fairy prion population however. His study emphasised that the tuatara-petrel relationship is complex, frequently aggressive, and almost exclusively favours the reptile (Walls 1978).

I, too, investigated tuataras and fairy prions using a series of study burrows on Stephens Island (Newman 1978). Between 1975 and 1978 I collected data on the use of burrows, movements and population densities of tuataras in two ecologically dissimilar areas of remnant forest. I discovered not only that tuataras use several burrows, but that several tuataras may use the same burrow, although at different times (Newman *et al.* 1979, Newman 1982b). Tuataras may vigorously defend the sole occupancy of a burrow but the activity ranges of animals often overlap. Tuataras restrict much of their activity to small areas around their burrows. At night, however, they may range widely searching for food, sometimes ascending trees. The greatest movement recorded of an individual was 63 metres in a straight line (Newman 1982b). From their occupancy of burrows, provisional estimates of tuatara density were made and these exceeded the equivalent of 600 animals per hectare (Newman 1982b). These density estimates appear quite remarkable for such a large reptile (see Turner 1977), especially for a carnivore which is a secondary and often tertiary consumer. The following explanations have been given (see Saint Girons *et al.* 1980, Newman 1982b). Firstly, the energy resources of islands like Stephens, where petrel guano provides a rich mineral soil, create conditions which encourage the development of a high biomass of ground-dwelling invertebrates which form the bulk of the tuatara's diet (Dawbin 1962, Crook 1974b, 1975). Secondly, tuataras have a low energy requirement. They have a lower metabolic rate at equable temperatures than most other reptiles (Milligan 1924, Wilson and Lee 1970), have an exceptionally slow growth rate (Dawbin 1962, 1982b) and live at relatively low temperatures. Presumably they use little energy and would therefore have low dietary requirements. The average density of tuataras over an entire island like Stephens would be considerably lower than that recorded in the areas studied. Stephens Island, however, probably supports at least 30,000 tuataras and possibly more than 50,000 (Newman 1982b).

While tuataras will, on occasion, eat the adults, chicks and eggs of fairy prions, my observations suggest that prions will aggressively defend their nests and are often able to drive off intruders — be they tuataras or non-breeding birds (Newman 1978). I have seen a tuatara (a mature male) hurriedly retreating from a burrow with a prion clinging to its tail. My impression is that during the prion breeding season, fairy prions and tuataras tend to avoid sharing burrows whenever possible. At this time, tuataras and fairy prions are more likely to be found sharing 'complex' burrows (those with several entrances and prion nest chambers) than 'simple' burrows (those having only one entrance and a single prion nesting chamber). Side passages, or unoccupied chambers, are often present in complex burrows where a tuatara may live without coming into contact with the nesting birds.

Although petrels appear to create conditions ideal for tuataras, I believe that the reptiles could survive in their absence; but under such circumstances it is unlikely that they would reach the high population densities that have been recorded on islands such as Stephens (Newman 1978).

Research carried out on the tuatara by the Wildlife Service has raised many intriguing questions. Evidence collected by Ian Crook (1973a, b) strongly suggests that tuataras cannot persist on islands where rats are present, but the exact causal relationships and how they may be modified by other factors are unknown. Tuataras co-existing with rats are almost all greater than 200mm snout-vent length (Crook 1973a, b), indicating a failure of recruitment, but it is not clear if this is the result of predation, competition, or a more subtle change in the ecological balance (see Whitaker 1978). To investigate reptile-rodent relationships, a long-term study has been started on islands in the Chickens Group, 35°54'S 174°44'E, to examine the population dynamics and feeding habits of both tuatara and kiore, their use of burrows, and their interactions with nesting seabirds. Particular attention will be given to the collecting of data on the potential and realised reproductive capacity of tuataras, both on rat-free and rat-occupied islands.

At present, little is known about the tuatara's reproductive potential. The breeding success of tuataras kept in captivity has been disappointingly poor (Newman *et al.* 1979, Newman 1982c). It is not known, for instance, whether

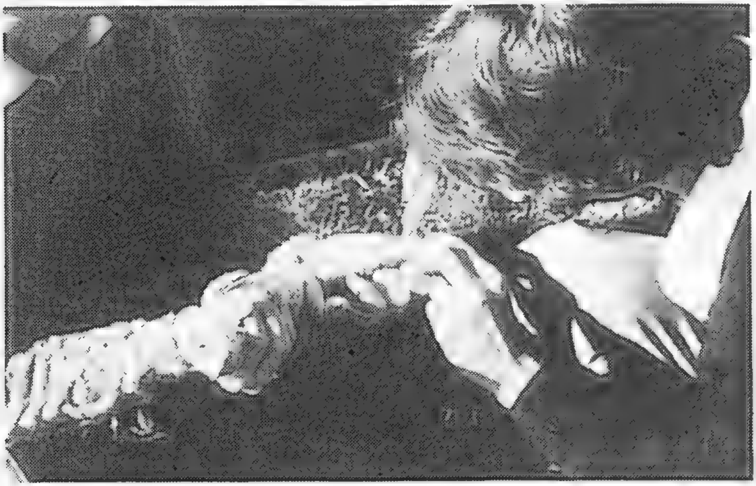


Figure 5 Collecting blood from the caudal vessels of a tuatara, Mt. Bruce Native Bird Reserve.

females lay eggs once every year or once every second or third year. No information is available on the proportion of mature females that breed each season, of the number of clutches produced or of their hatching success. Female tuataras never lay their eggs in burrows they occupy. They deposit eggs in specially constructed chambers which, once laying is completed, are filled up with soil and leaf litter then abandoned.

To enable the proportion of mature females that breed each season to be estimated, Mark Vickers, Palmerston North Animal Health Laboratory, Ministry of Agriculture and Fisheries, and I are currently trying to develop an indirect technique to determine the reproductive status of tuataras by monitoring their blood plasma content. Dessauer and Fox (1959) found that the ovoviviparous snake *Thamnophis sauritus* exhibits marked changes in plasma calcium, phosphorus, magnesium and total protein, as well as changes in plasma electrophoretic pattern, during maturation of follicles. Blood has now been collected from the caudal vessels of tuataras held at the Mt Bruce Native Bird Reserve and at Otorohanga (Otorohanga Zoological Society) using the technique described by Esra *et al.* (1975). Our preliminary results suggest that one of the four females tested so far may be carrying eggs.

In January 1980 the Wildlife Service, in conjunction with the Zoology Department, Victoria University of Wellington, sponsored a symposium on research and management of the New Zealand herpetofauna. The main purpose of the meeting was to enhance and encourage discussion and research on New Zealand's amphibians and reptiles. In addition, from discussions held throughout the symposium, the Wildlife Service has been able to allocate research priorities for dealing with its new responsibility: lizard protection (see Newman 1980, Newman [editor] 1982). We have just learnt that our application made to the National Research Advisory Council for an additional herpetologist has been successful. This position should be advertised shortly*. However, even with two scientists the Wildlife Service is inadequately endowed to undertake all the research necessary to conserve our rare lizards. For this reason we are extremely pleased about the setting up of a joint project, with members of the New Zealand Herpetological Society, to study the ecology of the Great Barrier or chevron skink, *Leiolopisma homalonotum.* The objectives of this study are to collect information on the distribution, habitat requirements, population dynamics, and feeding habits of *L. homalonotum* on Great Barrier Island, 36°11'S 175°25'E. Generally, the Wildlife Service is only too happy to support all research contributions, from any individual, from any organisation, now and in the future. Consequently, I look forward to many more projects involving both the Wildlife Service and the New Zealand Herpetological Society — working together to help conserve our unique herpetofauna.

References

BULL, P.C.; A.H. WHITAKER 1975: The amphibians, reptiles, birds and mammals. In : Kuschel, G. (Editor). *Biogeography and Ecology in New Zealand* pp. 231-276. Junk, The Hague.

CROOK, I.G. 1970a: Stephens Island frog. *Wildlife — A Review No. 2:* 13-16. NZ Wildlife Service, Department of Internal Affairs, Wellington.

1970b: Tuatara. *Wildlife — A Review No. 2:* 16-19. NZ Wildlife Service, Department of Internal Affairs, Wellington.

1973a: The tuatara, *Sphenodon punctatus* Gray, on islands with and without populations of the Polynesian rat, *Rattus exulans* (Peale). *Proceedings of the New Zealand Ecological Society 20:* 115-120.

1973b: Tuatara and the Polynesian rat. *Wildlife — A Review No. 4:* 47-48. NZ Wildlife Service, Department of Internal Affairs, Wellington.

1974a: The climate of a frog habitat. *Wildlife — A Review No. 5:* 41-

* Dr David R Towns has been appointed to this position.

42. NZ Wildlife Service, Department of Internal Affairs, Wellington.

1974b: Are tuataras dependent on petrels? *Wildlife — A Review No. 5:* 43-46. NZ Wildlife Service, Department of Internal Affairs, Wellington.

1975: The tuatara. In : Kuschel, G. (Editor). *Biogeography and ecology in New Zealand* pp. 331-352. Junk, The Hague.

CROOK, I.G.; I.A.E. ATKINSON, B.D. BELL 1971. Habitats of the frog *Leiopelma hamiltoni* McCulloch on Stephens and Maud Islands, Cook Strait. *New Zealand Journal of Science 14:* 1082-1093.

DAWBIN, W.H. 1949: The tuatara. *Tuatara 2:* 91-96.

1962: The tuatara in its natural habitat. *Endeavour 21:* 16-24.

1982: The tuatara, *Sphenodon punctatus* : aspects of life history, growth and longevity. In : Newman, D.G. (Editor). *New Zealand herpetology.* pp. 237-250. NZ Wildlife Service, Department of Internal Affairs, Wellington. Occasional Publication No. 2.

DESSAUER, H.C.; W. FOX 1959: Changes in ovarian follicle composition with plasma level of snakes during estrus. *American Journal of Physiology 197:* 360-366.

ESRA, E.N.; K. BENIRSCHKE, L.A. GRINDER 1975: Blood collecting technique in lizards. *Journal of the American Veterinary Medical Association 167:* 555-556.

HARDY, G.S. 1977: The New Zealand Scincidae (Reptilia : Lacertilia); a taxonomic and zoogeographic study. *New Zealand Journal of Zoology 4:* 221-325.

HARDY, G.S.; G.R.F. HICKS 1980: Proposed removal of *Leiolopisma* (?) *fasciolare* from the checklist of New Zealand Scincidae (Reptilia : Lacertilia), and a note on the name *Hombronia. New Zealand Journal of Zoology 7:* 425-426.

MILLIGAN, R.R.D. 1924: The respiration and metabolism of the tuatara. *Australasian Association for the Advancement of Science Report 16:* 404-406.

NEWMAN, D.G. 1977a: Some evidence of the predation of Hamilton's frog (*Leiopelma hamiltoni [McCulloch]) by tuatara (Sphenodon punctatus* [Gray]) on Stephens Island. *Proceedings of the New Zealand Ecological Society 24:* 43-47.

1977b: Hamilton's frog. *Wildlife — A Review No. 8:* 48-53. NZ Wildlife Service, Department of Internal Affairs, Wellington.

1978: Tuataras and petrels. *Wildlife — A Review No. 9:* 16-23. NZ Wildlife Service, Department of Internal Affairs, Wellington.

1980: Herpetological symposium. *Wildlife — A Review No. 11:* 39-47. NZ Wildlife Service, Department of Internal Affairs, Wellington.

1982a: A management plan for Hamilton's frog *Leiopelma hamiltoni* on Stephens Island. In : Newman, D.G. (Editor). *New Zealand Herpetology* pp.93-99. NZ Wildlife Service, Department of Internal Affairs, Wellington. Occasional Publication No. 2.

1982b: Tuataras, *Sphenodon punctatus,* and burrows, Stephens Island. In : Newman, D.G. (Editor). *New Zealand Herpetology* pp. 213-221. NZ Wildlife Service, Department of Internal Affairs, Wellington. Occasional Publication No. 2.

1982c: Breeding tuataras, *Sphenodon punctatus,* in captivity. In : Newman, D.G. (Editor). *New Zealand Herpetology* pp. 277-284. NZ Wildlife Service, Department of Internal Affairs, Wellington. Occasional Publication No. 2.

(Editor) 1982: *New Zealand Herpetology,* NZ Wildlife Service, Department of Internal Affairs, Wellington. Occasional Publication No. 2 495pp.

NEWMAN, D.G.; I.G. CROOK, Ch. IMBODEN 1978: Comparisons of the climates of the two habitats of Hamilton's frog (*Leiopelma hamiltoni* [McCulloch]). *New Zealand Journal of Ecology 1:* 84-90.

NEWMAN, D.G.; I.G. CROOK, L.R. MORAN 1979: Some recommendations on the captive maintenance of tuataras *Sphenodon punctatus* based on observations in the field. *International Zoo Yearbook 19:* 68-74.

ROBB, J. 1980a: *New Zealand amphibians and reptiles in colour.* Collins, Auckland. 128 pp.

1980b: Three new species of Gekkonid lizards, genera *Hoplodactylus* Fitzinger, and *Heteropholis* Fischer, from New Zealand. *National Museum of New Zealand Records 1:* 305-310.

ROBB, J.; R.A. HITCHMOUGH 1980: Review of the genus *Naultinus* Gray (Reptilia : Gekkonidae). *Records of the Auckland Institute and Museum 16:* 189-200.

ROBB, J.; R.P.V. ROWLANDS 1977: Reinstatement of *Hoplodactylus maculatus* (Boulenger) with a redescription of *H. pacificus* (Gray) (Reptilia : Squamata : Gekkonidae). *Records of the Auckland Institute and Museum 14:* 133-142.

SAINT GIRONS, H.; B.D. BELL; D.G. NEWMAN 1980: Observations on the activity and thermoregulation of the tuatara, *Sphenodon punctatus* (Reptilia : Rhynchocephalia), on Stephens Island. *New Zealand Journal of Zoology 7:* 551-556.

STEPHENSON, E.M.; N.G. STEPHENSON 1957: Field observations on the New Zealand frog *Leiopelma* Fitzinger. *Transactions of the Royal Society of New Zealand 84:* 867-882.

THOMAS, B.W. 1981: *Hoplodactylus rakiurae* n. sp. (Reptilia : Gekkonidae) from Stewart Island, New Zealand, and comments on the taxonomic status of *Heteropholis nebulosus* McCann. *New Zealand Journal of Zoology 8:* 33-47.

TURNER, F.B. 1977: The dynamics of populations of squamates, crocodilians and rhynchocephalians. In : Gans, C.; Tinkle, D.W. (Editors). *Biology of the Reptilia. Volume 7. Ecology and Behaviour A* pp 157-264. Academic Press, London.

WALLS, G.Y. 1978: The influence of the tuatara on fairy prion breeding on Stephens Island, Cook Strait. *New Zealand Journal of Ecology 1:* 91-98.

1981: Feeding ecology of the tuatara *(Sphenodon punctatus)* on Stephens Island, Cook Strait. *New Zealand Journal of Ecology 4:* 89-97.

WHITAKER, A.H. 1978: The effects of rodents on reptiles and amphibians. In : Dingwall, P.R.; Atkinson, I.A.E.; Hay, C. (Editors). *The ecology and control of rodents in New Zealand Nature Reserves* pp 75-86. Department of Lands and Survey Information Series No. 4, Wellington.

WILSON, K.J.; A.K. LEE 1970: Changes in oxygen consumption and heart-rate with activity and body temperature in the tuatara *Sphenodon punctatum. Comparative biochemistry and physiology 33:* 311-322.

THE HERPETOFAUNA OF THE MIDDLEBACK RANGE AREA, SOUTH AUSTRALIA
1. AN ANNOTATED CHECKLIST

By G. R. Johnston
c/o 16 McEwin Street, Whyalla Playford, South Australia 5600.

Summary

58 spp. of reptile, belonging to 8 families and 2 spp. amphibians, belonging to one family are listed for the Middleback Ranges, South Australia.

Introduction

This paper is the first of two which will cover the recent herpetofauna of the Middleback Ranges. The study area is described and an annotated checklist of species recorded there given. The second paper will deal with ecological relations and zoogeography.

The Middleback Ranges are a meridional line of low hills between latitudes 137°6'E and 137°12'E, and longitudes 32°57'S and 33°18'S, 35 kilometres west of Whyalla, on north-eastern Eyre Peninsula, South Australia. (See Figure 1).

Since 1973 members of the Western and South Australian Herpetology Groups have visited the ranges periodically. In 1979 delegates to the second convention of the Australasian Affiliation of Herpetological Societies visited the area. For the past two years the author has been surveying the ranges as part of The Broken Hill Proprietary Company Limited's environmental study programme. Consequently a large body of data on the herpetofauna of the Middleback Range area has been collected over a period of nine years.

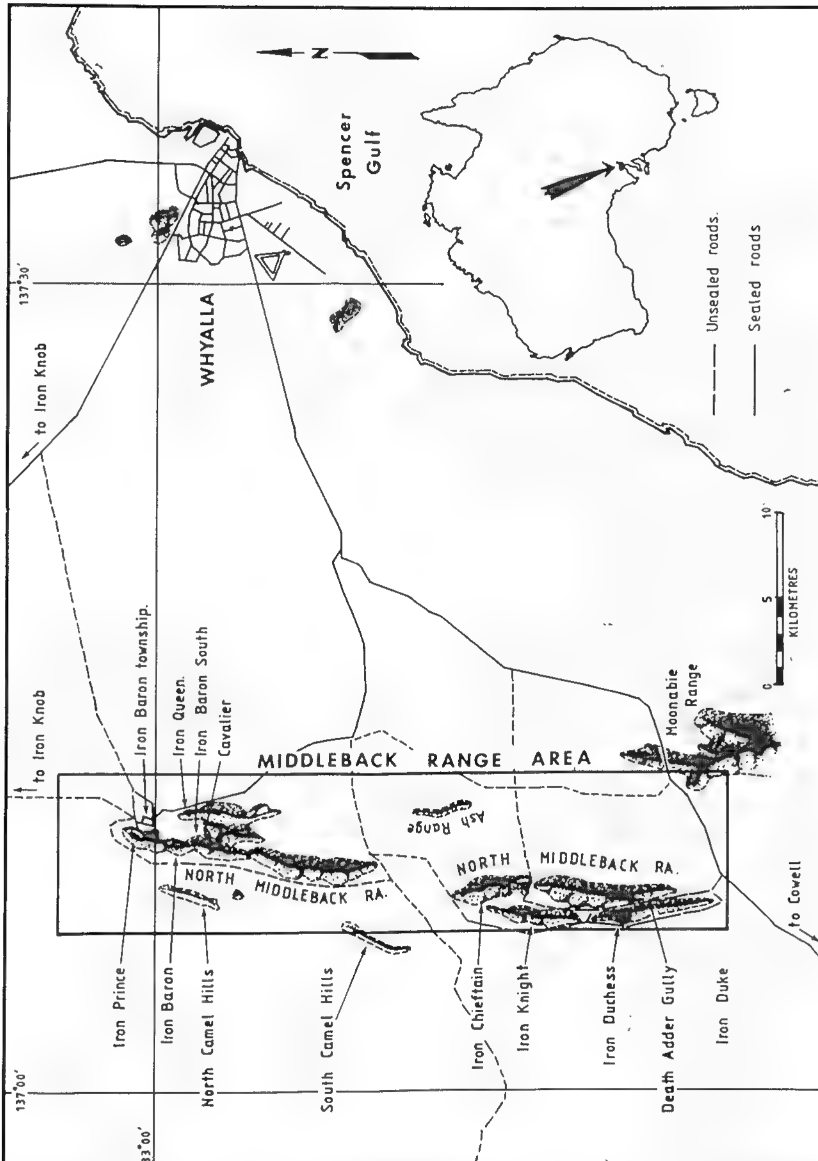
Little of this information has been published, however. Houston (1974) recorded the Range as a locality record for *Amphibolurus fionni.* Mirtschin (1976) and Hudson (1979) described captive births of *Acanthophis antarcticus* involving adults taken from Iron Duke. The South Australian Herpetology Group have written two reports on their work in the study area (1977 and 1979) and Galliford (1981) noted that *Nephrurus stellatus* had been collected there. The current series of papers summarise and perform a basic analysis of all of the data available from the above mentioned sources such that they may be readily available as a basis for future, more detailed, research.

Description of the study area

Laut *et. al.* (1977) recognised two major and six minor landsystem units in the Middleback Range area. The "Buckleboo Environmental Association" is characterised by gently undulating calcrete plains with occasional quartizite or granite hills and a vegetative cover of low open woodland or open mallee scrub. The environmental units are recognised within this association: undulating plains, hills and saltlakes. All are represented in the Middleback Range area. The "Middleback Range Environmental Association" is characterised by hogback ridges with long footslopes. Three environmental units are recognised for this association: ranges, footslopes and minor plains. All are represented in the study area.

Lemon (1979) has described the iron formations of the Middleback Ranges as a sedimentary series of early Proterozoic age which shows evidence of having undergone at least three phases of deformation. The flanks of the ranges have a cover of unconsolidated talus. The plains to the east of the ranges are covered by undifferentiated red-brown sandy clays and gravel over locally outcropping calcrete. A south-east trending dune system occurs to the west of the ranges.

A number of iron ore deposits in the Middleback Ranges are under lease by The Broken Hill Proprietary Company Limited. Mines have been operating in the Iron Baron and Iron Prince area since the 1930's. Iron Queen, Cavalier and Iron Baron South have been mined since the late 1970's. Other deposits are undergoing geological testing at Iron Duke, Iron Duchess and Iron Knight.



Centre Whyalla	THE BROKEN HILL PROPRIETARY CO LTD	Project No
Date	LOCALITY MAP OF MIDDLEBACK RA. AREA FIG. 1	Drawing No A4–

Grazing is the only other land use of any significance in the Middleback Range area. The population of the area is in the order of 250 people, most of whom live in the township of Iron Baron in the north and service the mines in that area.

The entire study area is over 120 metres above sea level. The highest point is Mount Middleback North which rises 432 metres above sea level.

Climatic data is limited. The only records available are from Iron Baron. Over the period 1978-1981 the average annual precipitation was 331 millimetres. Temperatures have only been recorded for one year and so an average temperature is not available. During the year for which records are available temperatures varied from a minimum of 9.0°C to a maximum of 47.3°C. Annual evaporation is in the order of 2,000 millimetres.

The Middleback Ranges lie across an ecotone between the mallee and arid-landsystems of Specht (1972). To the west and south of the Ranges the mallee landsystem is represented by *Eucalyptus oleosa — E. brachycalyx, E. socialis — E. gracilis* and *E. incrassata* Open Scrubs. To the east and north *Acacia papyrocarpa* Low Open Woodland interspersed with areas of *Casuarina cristata* Low Woodland dominate the arid landsystem. The Ranges themselves have a cover of *Casuarina cristata* Low Woodland interspersed with areas of *Triodia irritans* Hummock Grassland, *Beyeria leschenaultii — Eremophila* spp. — *Dodonaea* spp. Low Shrubland and *Callitris priesii* Open Woodland (Johnston, in. prep.). The vegetation of the Ranges and surrounding plains will be discussed in terms of recognisable habitat units.

Annotated checklist of the Herpetofauna

The herpetofauna of the Middleback Range area consists of sixty species. Two species of frogs belong to one Family and fifty-eight species of reptiles belong to eight Families. (See Table 1).

An annotated checklist of the herpetofauna of the Middleback Range area is presented below. It is arranged alphabetically by genus and species within suprageneric taxa. Taxonomy used is based on Cogger (1979) unless otherwise stated. The aim of this checklist is essentially to define the herpetofauna of the study area. Due to the relatively labile nature of herpetological taxonomy in Australia considerable time has been spent in specifying which populations are being dealt with (i.e. in terms of publications by King on geckoes), particularly in groups which are likely to be revised, so that the results of the second paper will be effected as little as possible. Considerable variation treatment of species in this list is, therefore, evident. Where a species is considered to be taxonomically stable and no worthwhile observations have been made of that species it is simply listed with no annotation.

TAXA	genera	species
AMPHIBIA		
Leptodactylidae	2	2
REPTILIA		
Gekkonidae	8	10
Pygopodidae	3	6
Agamidae	2	6
Varanidae	1	1
Scincidae	9	20
Typholopidae	1	2
Boidae	1	1
Elapidae	9	12
TOTALS:	36	60

Table 1: Taxonomic composition of the herpetofauna of the Middleback Range area.

S.A.M. = South Australian Museum

REPTILIA : ANURA
LEPTODACTYLIDAE

Lymnodynastes tasmaniensis SPOTTED GRASS FROG

Roberts (1976) has shown that *L tasmaniensis* is composed of three geographically distinct "call races". Specimens from north-eastern Eyre Peninsula belong to the race inhabiting the Flinders Ranges, Mount Lofty Ranges, Yorke Peninsula, Kangaroo Island and the periphery of the Coorong.

Found near any reasonably permanent supply of freshwater. Adults have been found in all dams investigated to date. Tyler (1979) has pointed out that man has acted as a mode of dispersal for this species in other areas. It is conceivable that *L. tasmaniensis* has been introduced to the Middleback Range area as it has only been found to date in artificial sources of water or areas with direct connections to artificial water sources.

Neobatrachus sp. BURROWING FROG

Nomenclature of the *Neobatrachus* frogs is very confused. Specimens from Eyre Peninsula have been variously called *N. pictus* (Tyler, 1978) and *N. centralis* (Cogger, 1979). Mahony (pers. comm., 1981) has hypothesised that the Middleback Range area lies within a hybrid zone between *N. pictus* on southern Eyre Peninsula and an undescribed *Neobatrachus* sp. which occurs further north.

Larvae from the Middleback Range area agree broadly with the description given by Watson and Martin (1973) for *N. pictus* in being active swimmers with plump bodies and short tails, having no papillae on anterior margin of the mouth disk, three rows of teeth on each labium and very robust jaws, but differ in detail.

REPTILIA : SQUAMATA
GEKKONIDAE

Diplodactylus elderi JEWELLED GECKO

One specimen has been taken from the Iron Duke area.

Diplodactylus intermedius EASTERN SPINY-TAILED GECKO

Represented in S.A.M. Reported for many localities in the South Middleback Range, also from Iron Knob to the north of the study area. Usually found perched in the foliage of *Atriplex* sp. (Ehmann, 1980), *Triodia irritans* or *Sarcostemma australe.*

Diplodactylus "vittatus" (2n = 34) STONE GECKO

King (1977a) has shown that *D. "vittatus"* consists of five morphologically distinguishable and karyotypically constant populations, each of which has been an extensive and discrete distribution. Specimens from the Middleback Range area agree with the morphological criteria for his 2n = 34 race.

Gehra "variegata" (2n = 44) VARIEGATED GECKO

King (1979) has distinguished three populations within *G "variegata"* on the basis of karyotype. Specimens from Iron Duke belong to the 2n = 44 race, which also occurs elsewhere on northern Eyre Peninsula and in the Flinders Ranges.

Found commonly among rock outcrops and in hollow logs.

Heteronotia binoei BINOE'S GECKO

Represented in S.A.M. Common in rocky areas.

Lucasium damaeum BEADED GECKO

Represented in S.A.M. One specimen was found in a trapdoor spider burrow.

Nephrurus stellatus STELLATE KNOB-TAILED GECKO

Common in sandy areas in the South Middleback Ranges.

Phyllodactylus marmoratus (2n = 36) MARBLED GECKO

Recorded from Iron Duchess. King (1977b) has shown that *P. marmoratus* is divisible into four chromosome races. Specimens from the Middleback Range area fall within the established geographical distribution of the 2n = 36 race.

Rhynchoedura ornata BEAKED GECKO

The South Australian Herpetology Group reported this species from the South Middleback Ranges in 1979.

Underwoodisaurus millii THICK-TAILED GECKO

PYGOPODIDAE

Delma australis

Delma fraserii FRASER'S LEGLESS LIZARD

Two specimens have been taken from Iron Duchess.

Delma nasuta

Lialis burtonis BURTON'S LEGLESS LIZARD

Two colour forms occur. Both have dark longitudinal stripes along the total length of the body and tail on a brown or grey base colour. Intermediates occur.

Pygopus lepidopodus COMMON SCALYFOOT

Recorded in S.A.M.

Pygopus nigriceps HOODED SCALYFOOT

AGAMIDAE

Amphibolurus cristatus CRESTED DRAGON

Amphibolurus fionni PENINSULA DRAGON

Houston (1974) recognised six races of this species. Specimens from the Middleback Ranges agree with his criteria for the central race, which is distributed in addition on the southern most remnants of the Arcoona Plateau and in the Gawler and Blue Ranges.

The dorsal colouration of these lizards matches very closely that of the lichen covered iron formation (jaspilite) outcrops which they inhabit.

Amphibolurus fordii MALLEE DRAGON

Amphibolurus pictus PAINTED DRAGON

Amphibolurus vitticeps BEARDED DRAGON

Recorded in S.A.M.

Moloch horridus THORNY DEVIL

Recorded in S.A.M.

VARANIDAE

Varanus gouldii GOULD'S GOANNA

SCINCIDAE

Cryptoblepharus plagiocephalus SNAKE-EYED SKINK

Recorded in S.A.M.

Ctenotus atlas

Ctenotus robustus ROBUST SKINK

The identity of a population of large *Ctenotus* which inhabit most of the hills on north-eastern Eyre Peninsula has been subject to debate for some time. Here they are called *C. robustus* as the majority of specimens from the Middleback Ranges resemble that species using Storr's (1971) and Cogger's (1979) keys, although a sizeable proportion resemble *C. saxatilis.* Represented in S.A.M.

Ctenotus schomburgkii SCHOMBURGK'S SKINK

Recorded in S.A.M.

Egernia inornata ROSEN'S SKINK

Egernia stokesii GIDGEE SKINK

Large colonies of *E stokesii* occur in areas of rock outcrop throughout the Range.

Egernia striolata TREE SKINK

Inhabits rock outcrops. Ehmann (pers. comm., 1981) has suggested that these animals may represent *E. formosa.* Here they have been called *E. Striolata* on the basis of the presence of expanded supracaudal scales, the character which Cogger (1979) uses to distinguish these two species.

The South Australian Herpetology Group (1979) have suggested that the population of *E. striolata* inhabiting the Middleback Ranges may be subspecifically or even specifically distinct.

Eremiascincus richardsonii RICHARDSON'S BANDED SKINK

This species is listed on the basis of one specimen taken from the gut of a "DOR" death adder on the highway immediately south of Iron Duke.

Hemiergis millewae

Lerista picturata edwardsii TWO-TOED BURROWING SKINK

Lerista frosti

Lerista muelleri

Menetia greyi

Morethia adelaidensis

Morethia boulengeri

Ehmann (pers. comm., 1979) has noted that specimens from the Middleback Ranges have less rufous on the tail than eastern Australian *M. boulengeri.*

Tiliqua branchialis GUNTHER'S SKINK

Found in *Triodia.* Diurnal. Specimens from the Middleback Ranges are slate grey-brown in colour and may more properly be referable as *T. melanops.*

Tiliqua occipitalis WESTERN BLUETONGUE

Tiliqua rugosus SLEEPY

The use of *Tiliqua* rather than *Trachydosaurus* here follows Hutchinson (1980).

Tiliqua scincoides COMMON BLUETONGUE

TYPHLOPIDAE

Ramphotyphlops australis

Ramphotyphlops is used here following Stimson, Robb and Underwood (1977).

Ramphotyphlops bituberculata

BOIDAE

Python spilotes CARPET PYTHON

Recorded in S.A.M. (R 14261) from "Iron Monarch". In fact this specimen was taken at Iron Duchess by the Western Herpetology Group.

ELAPIDAE

Acanthophis antarcticus DEATH ADDER

Recorded in S.A.M. Occasionally found on roads at night, or amongst leaf litter by day. A valley in the South Middleback Range has been named Death Adder Gully as this species is reputed to be particularly abundant there. Grey and red individuals occur in the study area.

Demansia psammophis reticulata YELLOW-FACED WHIP SNAKE

Drysdalia mastersii MASTER'S SNAKE

One dead on road specimen taken from Iron Knight.

Echiopsis curta BARDICK
Pseudechis australis KING BROWN SNAKE
Pseudonaja nuchalis WESTERN BROWN SNAKE

Usually fawn brown dorsal colouration with dark nape patch and yellow venter.

Pseudonaja textilis inframacula COMMON BROWN SNAKE

Typically grey dorsal colouration with dark grey venter. In this and the preceding species considerable variation from usual colouration many occur.

Simoselaps bertholdii DESERT BANDED SNAKE
Simoselaps semifasciatus HALF-GIRDLED SNAKE
Suta suta CURL SNAKE
Unechis brevicauda MITCHELL'S SHORT-TAILED SNAKE
Unechis gouldii GOULD'S SNAKE

Discussion

Due to the length of time and intensity of field work undertaken the species list presented for the Middleback Range area may be considered comprehensive.

Cogger and Heatwole (1981) have produced a series of species density maps for the families of Gekkonidae, Pygopodidae, Agamidae, Varanidae, Scincidae and Elapidae. These maps were based on Cogger (1975) and serve as approximations of the numbers of species in each of these families which one would expect in a given study area. Table 2 compares the expected and actual species totals for each of the families dealt with by Cogger and Heatwole in the Middleback Range area. From this table one can see that, within the reliability of the expected number of species, there are no significant discrepancies between actual and predicted numbers of species in any of the six families for the Middleback Range area.

FAMILY	EXPECTED NUMBER OF SPECIES	ACTUAL NUMBER OF SPECIES
Gekkonidae	10	10
Pygopodidae	6	6
Agamidae	8	6
Varanidae	2	1
Scincidae	20	20
Elapidae	10	12

Table 2: Comparison of expected and actual number of species of six reptilian families in the Middleback Range area.

The taxonomy of the Australian herpetofauna is still relatively labile. This state of affairs prompts one to question the value of regional species lists such as the one prsented here in the sense that names may change and thus any analysis of these lists will be negated. Provided, however, that conclusion is kept to a local level nomenclatural changes are not perceived as being a problem. In the Middleback Range area, for instance, the populations of reptiles and amphibians inhabiting the area are well known. Any name changes which occur in the future will simply mean that each population may be called something else. It will not effect the fact that a population still exists in the area and interacts with other populations in the same area in a certain way.

Acknowledgements

This paper is based on the work of several herpetologists who have visited the Middleback Range are over the past nine years. All have been attached to

member societies of the Australasian Affiliation of Herpetological Societies. Particular acknowledgement is made of Dr. J. White and Mr P. J. Mirtschin for providing records of respectively the South Australian Herpetology Group's and Western Herpetology Group's visit to the study area. Mr H.F.W. Ehmann gave access to his personal field notes of the Australasian Affiliation of Herpetological Societies field trip in 1979. Ms Adrienne Edwards provided a list of species for which specimens are held by the South Australian Museum from the Middleback Ranges. Messrs P. Hudson and W. Ingall accompanied me on many enjoyable nights of spotlighting.

The Broken Hill Proprietary Company Limited gave permission to publish this paper which was collated originally as a part of that Company's environmental study programme.

References cited

COGGER, H.G. (1975): *Reptiles and Amphibians of Australia,* 1st Ed., A.H. & A.W. Reed : Sydney.

(1979): *Reptiles and Amphibians of Australia,* 2nd Ed., A.H. & A.W. Reed : Sydney.

COGGER, H.G. and H. HEATWOLE (1981): The Australian reptiles : origins, biogeography, distribution patterns and island evolution, *In* Keast. A. (Ed.), *Ecological Biogeography of Australia,* Junk : The Hague.

EHMANN, H.F.W. (1980): Diurnal perching by the Southern Spiny-tailed Gecko, Diplodactylus intermedius. *Herpetofauna,* 12 (1) : 37.

GALLIFORD, M. (1980): Notes on the starred knob-tailed Gecko, *Nephrurus stellatus,* caught spotlighting. *Herpetofauna,* 12(2):33-34.

HOUSTON, T.F. (1974): Revision of the Amphibolurus decresii Complex (Lacertilia : Agamidae) of South Australia, *Trans. Roy. Soc. S. Aust.* 98(2):49-60.

HUDSON, P. (1979): On the birth and breeding of Death Adders in captivity, *Herpetofauna,* 11(1):11-13.

HUTCHINSON, M.N. (1980): The systematic relationships of the genera *Egernia* and *Tiliqua* (Lacertilia : Scincidae). A review and immunological reassessment, *In* Banks, C.B. and Martin, A.A. (Eds) *Proceedings of the Melbourne Herpetological Symposium,* Zoological Board of Victoria, pp. 176-193.

JOHNSTON, G.R., (in prep): A vegetation survey of the Middleback Ranges, South Australia, Broken Hill Prop. Co. Ltd. Confidential Report.

KING, M. (1977a): Chromosomal and morphometric variation in the gekko Diplodactylus vittatus (Gray), *Aust. J. Zool.,* 25(1):43-57.

(1977b): An additional chromosome race of Phyllodactylus marmoratus (Gray) (Reptilia:Gekkonidae) and its phyllogenetic implications, *Aust. J. Zool.,* 25(4):667-672.

(1979): Karyotypic evolution in Gehyra (Gekkonidae:Reptilia) 1. The Gehyra variegata-punctata complex, *Aust. J. Zool.,* 27:373-393.

LAUT, P., P.C. HEYLINGERS, G. KEIG, E. LOFFLER, C. MARGULES, R.M. SCOTT, and M.E. SULLIVAN (1977): *Environments of South Australia. Province 4. Eyre and Yorke Peninsulas,* Division of Landuse Research, Commonwealth Scientific and Industrial Research Organisation, Australia.

LEMON, N.M. (1979): The Middleback Subgroup, *In* Parker, A.J. (Ed.) *Symposium on the Gawler Craton — extended abstracts,* Geol. Soc. Aust. (S. Aust. Division) Inc., pp.25-27.

MIRTSCHIN, P.J. (1976): Notes on breeding of Death Adders in captivity, *Herpetofauna,* 8(2):16-17.

ROBERTS, J.D. (1976): *Unpublished Ph.D. Thesis,* University of Adelaide. Cited in Tyler (1978).

SOUTH AUSTRALIAN HERPETOLOGY GROUP (1977): *Report of a trip to Middleback Ranges, Eyre Peninsula,* January 29-31, 1977, Unpublished Report.

(1979): *Report of field trip to Middleback Ranges,* March 24th, 1979, Unpublished Report.

SPECHT (1972): The Vegetation of South Australia, 2nd Ed. Govt Printer, Adelaide.

STIMSON, A.F., J. ROBB and G. UNDERWOOD (1977): Leptotyphlops and Ramphotyphlops Fitzinger, 1843 (Reptilia:Serpentes) — proposed conservation under the plenary powers. Z.N.(S) 2155, *Bull. Zool. Nomencl.*, 33(3/4):204-207.

STORR, G.M. (1971): The genus Ctenotus (Lacertilia:Scincidae) in South Australia, *Rec. S. Aust, Museum,* 16(6):1-15.

TYLER, M.J. (1978): *Amphibians of South Australia,* Govt. Printer:Adelaide.

——— (1979): The impact of European man upon Australasian Amphibians, *In* Tyler, M.J. (Ed.) *The status of endangered Australasian wildlife,* Roy. Zool Soc. S. Aust. pp. 177-184.

WATSON, G.F. and A.A. MARTIN (1973): Life history, larval morphology and relationships of Australian Leptodactylid frogs, *Trans. Roy. Soc. S. Aust.,* 97(1):33-45.

THE NATURAL HISTORY AND CONSERVATION STATUS OF THE ADELAIDE PIGMY BLUETONGUE LIZARD Tiliqua adelaidensis.

H. Ehmann, School of Biological Sciences, Sydney
Technical College, Broadway 2007. Australia.

ABSTRACT

The natural history of the scincid lizard *Tiliqua adelaidensis* probably encompasses the following [features]: a diurnal terrestrial/fossorial inhabitant of compacting or crusty sandy soils carrying mallee scrub and chenopodiaceous understorey with hollow mallee lignotubers and associated low stump hollows and near-surface kunkar limestone sheet, outcropping or large slab floaters; a burrower into moisture pockets/depressions on or between kunkar sheeting, under outcroppings and slabs, between mallee lignotubers and sheeting and into insect-hollowed lignotubers and trunks; a user of relatively short and hard-rimmed refuges in wood and stone; able to form tight lateral tail bends (ie tuck in tail); a diet generalist (opportunist) taking a wide range of mostly invertebrate and some plant material; not an active forager but rather an ambush predator.

The view that it is an hybrid form is not supported. The three specimens from the two precise localities (Dry Creek and Marion) may have arrived there in mallee root firewood. The localities Buchsfelde, Adelaide and North Burra are almost certainly despatch points only.

Only eleven specimens are known and intensive field work on the Adelaide Plain and Murray Mallee has failed to find any living specimens since the last two were taken in 1959. Clearing land of scrub mallee roots, limestone outcrops and floaters, kunkar mining, and mouse plagues (*Mus musculus*) are/were probably the major factors contributing to the lizard's decline. It is considered to be endangered and inclusion in the IUCN Red Data Book is proposed.

INTRODUCTION

The type description of *Cyclodus Adelaidensis* Peters 1863 contains a brief sentence on the species' ecology: "Kommt nur auf sandigem, steinigen Terrain vor" [Occurs only on sandy, stony terrain.] This sentence is in quotation marks, indicating that its source was correspondence from Richard Schomburgk (who sent the specimens to W. Peters from Buchsfelde near Adelaide).

Boulenger (1887) placed Peter's species in the genus *Tiliqua* apparently on the basis of a single specimen sent to Albert Gunther by Gerrard Krefft.

Waite (1929, p146) cast doubt on the validity of the taxon stating ". . . no one here has been able to identify a lizard with the description. Messrs Lucas and Frost suggest that the name was supplied to a young form of one of the larger species." Waite actually coined the common name Doubtful Bluetongue.

Mitchell (1950) revised the genera *Tiliqua* and *Egernia* and in the course of rearrangement and registration of old spirit collection material at the South Australian Museum he identified six specimens of *Tiliqua adelaidensis.*

In October 1959 two live specimens were found by builders labourers in a new suburban development at Marion near Adelaide. This find was reported in "The News" of 23 October 1959 (page 5) and the short report included a photograph of John Mitchell the late Francis holding a live specimen. This is the only known photograph of a living specimen despite thorough searches of John Mitchell's extent slide collection (Mitchell also was former Curator of Vertebrates, South Australian Museum a leading wildlife photographer at the time).

Eleven specimens are known to me: eight in the South Australian Museum Adelaide, two in the Zoologisches Museum Humbolt-Universitat Berlin, and one in the British Museum (Natural History) London. Most of the specimens are accompanied by meagre data, which I believe are in some cases unintentionally misleading.

The purposes of this paper are (1) to summarise the available specimen and natural history data, (2) to correlate aspects of functional morphology and anatomy with possible ecological characteristics of the species, and (3) to put forward some possible reasons for its rarity or demise.

METHODS

Seven spirit specimens held in the South Australian Museum (S.A.M.) were examined (Table 3).

Field work covered the Adelaide Plain (380 hours), Sedan-Swan Reach area (50 h), Yorke Peninsula (95 h), mallee areas east of Burra (62 h). In each of these major areas pit-traps with drift fencing were extensively used. Marion (25 h) and Dry Creek (38 h) were also searched. This field work was carried out irregularly over a span of twelve years mostly in spring and summer (total field man hours 650).

Herpetologists, collectors and others who had any first hand experience or knowledge of *adelaidensis* were contacted.

Specimens of other species used for illustration are designated by field number in the tables. At least two other specimens (with substrate data) of each of these species were examined (Table 2).

Storr (1976) placed some of the tiliquine species in the genus *Omolepida;* so as not to obscure (for the majority of readers) the close relationships of the species I have chosen to treat them all as genus *Tiliqua* (see also Cogger 1979 p584,5).

Archival material in the following institutions was searched: Australian Museum Sydney; British Museum (Natural History) — BM (NH); Gawler Institute; Mitchell Library — Sydney; South Australian Archives; South Australian Botanic Gardens; South Australian Museum — SAM; Zoologisches Museum (Humbolt-Universitat zu Berlin) — UHZ.

SPECIMEN HISTORIES

The two Buchsfelde specimens (syntypes)

Buchsfelde was renamed Loos in 1917 and is located on Section 44 in the Hundred of Mudla Wirra (Medwell *in litt.* 1981). It is 4.8 km WSW of Gawler South Australia.

R. Schomburgk was curator of the Museum of the Gawler Institute between 1861 & 1865. His quoted *in litt.* notes in Peters (1863) indicate that he collected widely on the Adelaide Plain and Hills eg. (translated from the German)

1. *Chelodina longicollis* — "From the upper parts of the Gawler [River]."
6. *Amphibolurus barbatus* — "In undergrowth on sand dune slopes."
7. *Amphibolurus decresii* — "Only on rocky banks of watercourses in the hills."
15. *Cyclodus gigas* [= *Tiliqua scincoides*]. — "In 13 years residence in South Australia this is the only specimen that I have found, I recovered it from a cat in the vicinity of the coast."
21 *Morethia anomala* — "On the banks of Victoria Creek" [The watercourse flowing through Williamstown].

Dr. G. Peters (pers. comm. 1982) kindly searched for the Schomburgk correspondence in the Humbolt University Zoologisches Museum but unfortunately it apparently no longer exists.

The British Museum Specimen.

Krefft's letter to Gunther of May 21, 1864 (photocopy in Australian Museum Archive) states that a separate list of specimens was to be forwarded. This list of 54 specimens (with British Museum receipt date "July 1864") includes specimen "40 *Hinulia* South Aust." amongst twelve other South Australian (sometimes more specifically — Adelaide) specimens. Four of these specimens (but not number 40) and other South Australian material stated by Krefft to have been received from R. Schomburgk is discussed in some detail in the letter. I have little doubt that Krefft's *adelaidensis* specimen came from Schomburgk. The possibility that George Masters (Assistant Curator and collector-at-large for the Australian

Museum, Sydney, 1864-1874) took the specimen can be excluded: he collected in South Australia from September to November 1865 at Adelaide, Port Augusta, Port Lincoln and the Flinders Ranges (Whitley, 1971).

Gunther to Krefft (19 Sept. 1864) confirmed or assigned names to 14 of the 54 listed specimens but not number 40. Its determination and others were to follow (original letter in Mitchell Library — A262).

Krefft to Gunther (20 Nov. 1864) requests names (identifications) of several specimens including number 40 (photocopy of letter in Australian Museum Archive).

In subsequent available correspondence the specimen is not mentioned again and Gunther (1867) published as follows, "20. Cyclodus Adelaidensis (Ptrs) Adelaide (Krefft, 40)".

The Dry Creek specimen

The Dry Creek specimen (R2229) was collected and presented to the South Australian Museum by E.T. Dean. Mitchell (1950) designated this specimen as a topotype and redescribed the species from it. In the register R2227, R2228 & R2229 are bracketted in the Remarks column followed by a statement about these six specimens being the first to be identified as the species *adelaidensis* since Peters original description. Also behind this bracket is the date 15 April 1899, implying all six were collected at that time. This is contradicted by the 1945 date for the two Burra specimens (R2228, see below). It is also unlikely that the date applies to the three "Central South Australian" specimens (R2227, see below). The Dry Creek specimen is probably the one to which the 15 April 1899 collection date applies.

In the Register (R2229) associated with there is a pencilled statement "[taken opposite Railway Station under stone]" and its source is uncertain: it is not in John Mitchell's usual hand style and his last assistant could not identify the writer or source of the statement (C. Houston 1981 pers. comm.). It was presumably added before John Mitchell's appointment as the handwriting is not in the style of museum workers who came after him. The register was started in 1911 (Hale 1956, p208).

The Three Central South Australian specimens.

Three faded specimens (Mitchell's R2227 a, b, c = now R8589, R8588 & R2227 respectively) were reported by Mitchell (1950) to have been labelled in the old (non-registered) collection as "*Omolepida* or *Egernia* sp — Central South Australia" by A. Zeitz. Their faded condition and pinholes in their intact extremities indicate they had been on display for some time. On re-registration of R8588 & 9 a date of capture of 1929 was entered, but this is most unlikely in view of the bracketted date associated with R2227, 8 & 9 (see above) and also A. Zeitz's service history (see below).

A. Zeitz joined the S.A. Museum in 1884 and was from available accounts a methodical, meticulous and most reliable curator. From 1884 until retirement in 1909 he was almost solely responsible for the identification, curation, and displays of specimens (Hale 1956). It seems most unlikely that these undetermined specimens were ever on display at the S.A. Museum, rather they were probably received from a displaying collector or other museum. It is possible they came from the Gawler Museum (part of the Gawler Institute) of which R. Schomburgk was curator in the early 1860's.

The broad locality A. Zeitz wrote was probably the best he could do with material received from others (explorers etc). A number of fish specimens labelled by him have similarly broad localities (J. Glover 1982 pers. comm.). From available records A. Zeitz's northernmost field work was at Lake Callabonna in north eastern South Australia (Hale 1956) and throughout his tenure at the South Australian Museum (1884-1909) South Australia included the Northern Territory (1863 to 1911 — Anon 1968 p14). Central South Australia to A. Zeitz was almost

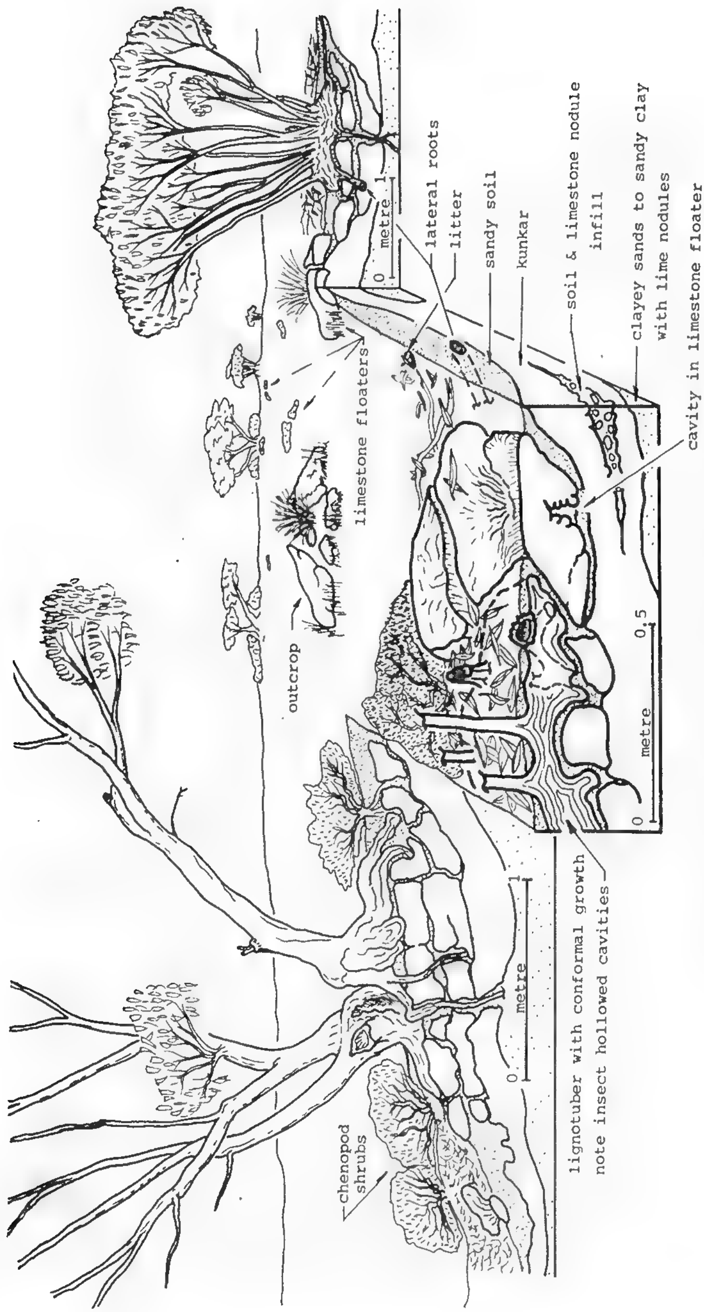


FIGURE 1. MALLEE GROWTH IN SANDY SOIL ON KUNKAR LIMESTONE
~ or ≀ = drawing truncated; low tree density
drawn for clarity.

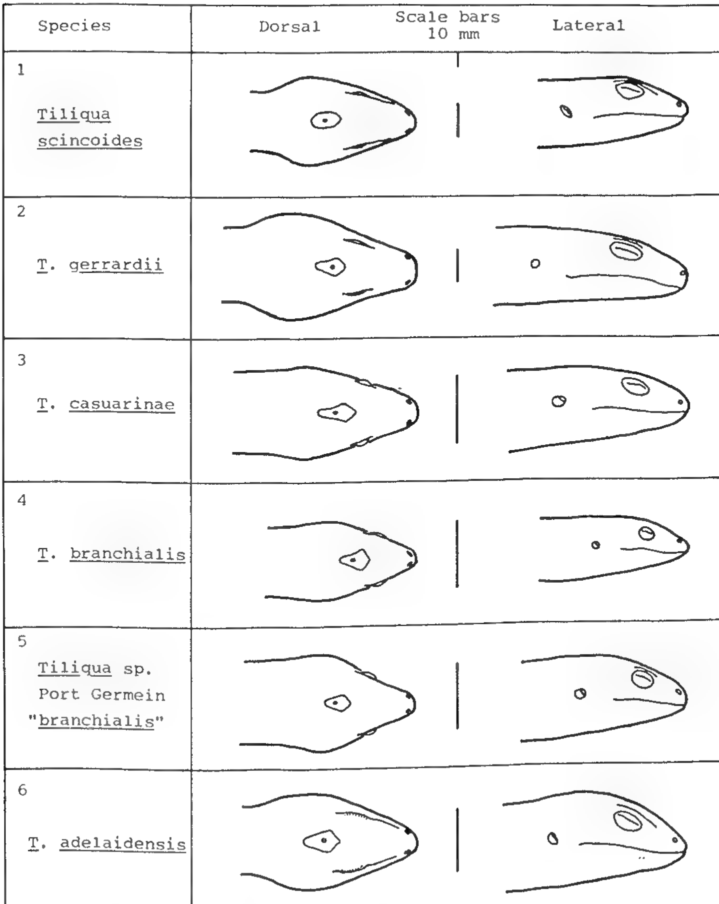


FIGURE 2. HEAD SHAPES OF ADULT *Tiliqua* (except *scincoides* which is drawn from a half-grown specimen).

All details from preserved specimens in good condition and verified in living material (except for *adelaidensis*).

Dorsal aspects show parietal scale with parietal "eye", outer edge of closed eyelids, brow and canthal ridge condition (in species 4 & 5 canthus rostralis co-incides with snout outline).

Lateral aspects show ear opening (with lobules), extent of fine-scaled "soft" peri-ocular tissue (with closed lids' margin), and the extent of the brow ridge (only the section which forms a firm *overhanging margin* is shown).

certainly the present day far northern S.A. and southern N.T.

Dr. Jessup (1982 pers. comm.) of the South Australian Botanic Gardens and Herbarium indicated that many of the plant specimens in the extensive Schomburgk collection were accompanied by similarly indefinite broad locality data.

In 1924 (G. Pretty 1982 pers. comm.) "the Gawler collection, quite large and still carefully preserved was handed over to the South Australian Museum" (Hale 1956, p13). A manuscript report on 159 mostly ethnological specimens exists in the S.A. Museum archives which Philip Jones kindly brought to my attention. This report refers to a manuscript ' "Catalogue of the Museum of the Gawler Institute, prepared by Otto Wehrstedt Marc?? 1881" on loan'. Presumably this was from the Gawler Institute. Searches by the present custodians of the Gawler Institute Archives have unfortunately not located this document (Mr. John Clift: 1982 pers. comm.).

The two North Burra specimens.

These were received by the S.A. Museum from near Burra in 1945 (Mitchell 1950). They are registered from the locality "North Burra, presented by Mr. A.E. Trueman Copperhouse near Burra" (Mitchell's R2228 a, b = now R8587 & R2228 respectively). On re-registration R8587 was erroneously entered as collected in 1929. I have had the good fortune to meet Mr. Trueman and discuss recollections of his natural history interests during his teaching service in the mid north of South Australia. Unfortunately he could not specifically recall the specimens although "they rang a bell" (after examining copies of correspondence between himself and S.A. Museum staff, and also coloured photographs of the preserved specimens particularly a side-on view of the head). His children and students often brough reptile and other specimens to him. Many of these were sent to a lecturer in nature studies at the Adelaide Teachers' College one Mr. Machell. He took the *adelaidensis* specimens to the S.A. Museum where they were identified by John Mitchell (*in litt.* — S.A. Museum Herp. Dept. corresp. to A.E. Trueman of 6 March 1946). This letter was received by Mr. Trueman but unfortunately he did not receive the letter of 30 Aug. 1946 seeking further and more precise collection information (Trueman 1981 pers. comm.).

Mr Trueman recalled that he and his family used to go to the Mongalata, Red Banks and Stone Hut Creek areas east of the ranges for outings during which they "grubbed out mallee roots for firewood". A favourite spot was Red Banks — "the first scrub you pass through travelling east out of the ranges and after passing the Mongalata turnoff".

The two Marion specimens.

The last known specimens (1959) were taken to John Mitchell by Albert Fischer an Adelaide amateur herpetologist who recognised their importance. A friend of his had been working on a building site with a gang of laborers. One of them had notices a lizard go into a hole under an old concrete slab that had been a shed floor. Some leftover hot billy tea was poured into the hole by one of the laborers. The lizards swam out and were caught and taken to Albert Fischer. One of the specimens (R4307a — now an alizarin skeletal preparation) soon died from the effects of the hot tea, the skin of the toes split and peeled away from the underlying tissue (all preceding information on Marion specimens is from A. Fischer 1979, 1980 pers. comm.).

The burrow was probably short (a billy of leftover tea more than filled it) and it either had a wide opening or was in a depression at the edge of the concrete slab (forming something of a pondage in which swimming was observed).

John Mitchell kept the living specimen (R4307b) in a small glass tank (about 40 x 25 cm ground area) with dry sand and a sheet of bark for shelter (Tyler 1981 pers. comm.). Despite the fact that it ate readily and frequently the animal became thin and after about six weeks it was narcotised and preserved (Fischer 1980 pers. comm.). Its preserved condition indicates dehydration contributed significantly

to this thinning. The species apparently needs access to relatively humid microhabitats.

These specimens are registered as having been collected in March 1960, but this is in error (News article date 23 October 1959, Fischer's information).

FIELD SEARCHES AND HABITAT ASSESSMENT

The search for "sandy stony terrain" that would permit a lizard the size and shape of *T. adelaidensis* to burrow under stone slabs was concentrated on the Adelaide Plain between Adelaide, Balaklava, the coast and the foothills of the Mt. Lofty Ranges with emphasis in the Gawler-Two Wells-Mallala triangle. The few relatively natural habitat remnants of the pristine Adelaide Plain in the south of this triangle indicate the area had extensive fixed low sand dunes separated by intervening sandy loam swales with shallow limestone underlying the dunes' lower slopes and the swale areas. In the lower dune areas this sheeting tended to develop low rubbly outcrops. The swale areas were littered with embedded stones, dislodged sheet fragments ("floaters") and in places outcroppings. Mallee vegetation with its distinctive lignotuber growth dominated on the shallow sandy soils overlying the kunkar sheeting. The lignotubers tend to conform in growth shape with depressions, fissures and buried limestone slabs.

The typical nature of kunkar sheeting, soil and mallee lignotubers is shown in Fig. 1.

Scrub clearing and stone gathering practices and limestone quarrying have dramatically reduced this habitat type on the Adelaide Plain. Almost every remaining outcrop shows signs of substantial early non-mechanised removal of large building sized stones. The abundance of older limestone town & farm buildings, ruins and many old Adelaide limestone-walled houses indicates massive export of limestone from the natural habitat. Road building has also utilised large quantities of both gathered limestone (paddock heaps) and later quarried kunkar sheeting. Lignotubers were carted to towns and Adelaide as mallee root firewood.

The intact kunkar sheeting depressions trap drainage waters forming underground "puddles" after heavy rain or at least regions of enhanced soil moisture after moderate rain. These "flood" conditions were observed in the field during the wet August of 1981, and they were also simulated experimentally in the field.

ASPECTS OF FUNCTIONAL MORPHOLOGY

1. *Head and body*

The cross sectional area of *adelaidensis* is greatest in the mid head region. Minimal cross sectional areas of the body and limb girdles in the living lizard would occur on full exhalation and during compression against restrictive obstacles. *T. adelaidensis* is similar (in having a proportionally large head) to the related Bluetongue *T. scincoides* and Pinktongue *T. gerrardii* (in the exhaled state). The large head is used by the latter two species to "test" the passage size and fit of hastily sought refuge holes or crevices in unyielding substrates or materials. (See head shapes, Fig. 2.) The She-oak Skink *T. casuarinae* and *T. branchialis* as adults have a head cross sectional area that is usually less than that at midbody. These lizards inhabit substrates that yield when penetrated (grass matting & leaf litter and *Triodia* hummock grasses).

This suggests *adelaidensis* inhabits hole refuges in unyielding substrates. There is an abundance of these in mallee lignotubers, kunkar surfaces, and in the spaces between these two.

A relatively compressible and low cross sectional area body also eases turning in hastily sought confined spaces (blind holes).

The anterior top of the head of *adelaidensis* is noticeably flat and the shields are slightly but significantly rugose. One function for this state may be to retain a

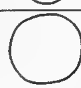
Species & number of specimen used for illustration Tables 1 & 2	Tail: S-VL ratio & S-VL (mm)	Tail cross section *	Scale: 5 mm	Tail H:W	Distal ⅓ to ½ tail noticeably paler no. examined	Peritoneum	
						strong black lining	diffuse pigment with darker ribs **
Egernia whitii HE G406	1.76 ♀ 105			1.03	– n = 8	+	
Egernia multiscutata HE 1580	1.41 ♂ 87			1.00	– n = 7	+	
Egernia inornata HE 0931	1.28 ♂ 65			0.99	2 of 8 specimens n = 8	+	
Tiliqua scincoides HE 1453	0.56 ♂ 177			0.95	– n = 12		+
Tiliqua gerrardii HE 0101	0.87 ♂ 195			1.27	– n = 6		+
Tiliqua casuarinae HE 0111	1.48 ♀ 135			1.01	2 of 11 specimens n = 11		+
Tiliqua branchialis HE 0632	1.11 ♂ 95			0.99	+ n = 14		+
Tiliqua sp. Pt Germein HE 1587	0.89 ♀ 95			1.04	+ n = 6		+
Tiliqua adelaidensis SAM R2229	0.57 ♀ 97			1.75	+ n = 7	+	

TABLE 1. TAIL MORPHOLOGY AND PERITONEAL LINING CONDITION.

HE = H. Ehmann Field Number, SAM = South Australian Museum,
S-VL = Snout-vent length, H:W = Height: Width Ratio.

* at one adpressed hindlimb's length.

** The lining is only sparsely pigmented and the peri-costal regions are noticeably dark (black).

their low level climbing habits in matted and hummocked vegetation respectively.

In the species studied, the more distal subdigital lamellae have an accute angled profile in species that inhabit homogeneous fine sandy soils (*E. inornata, T. casuarinae* and *branchialis*). Only the penultimate lamella is so shaped in the undescribed *Tiliqua* from Port Germein. The species inhabiting heterogeneously textured substrates (*E. whitii, multiscutata, T. scincoides, Tiliqua* sp. — Pt Germein) have obtusely angled and more or less rounded subdigital lamellae profiles.

The distribution of callosed tissue on the subdigital lamellae of inhabitants of

small layer of litter or soil as camouflage as is seen sometimes in the similarly rugose Death Adders *(Acanthophis).* This would be an advantage if *adelaidensis* ambushes prey from concealment eg. burrow, litter blanket etc.

2. *Tail*

The tail is vertically compressed and relatively short (see Table 1) and in preservative can set with two small 180° bends (minimum radius of larger one = 0.09 tail length, tail length to S-V ratio = 0.57). This contrasts markedly with *T. scincoides* which can set with one wider 180° bend (min. radius = 0.20 tail length, tail length to S-V ration = 0.56).

The maintenance of the original or near original capital tail condition (seen in all 7 examined spirit specimens) may indicate a lack of or reluctance to use radical autotomic capacity (ie. all or none of the lizard falls prey), or high success in predator avoidance. Whatever the case an original tail may be of considerable importance to *adelaidensis.* Substantially regenerated tails in other similar sized skinks cannot bend or flex as tightly or freely as an original tail.

The large *Tiliqua* skinks (which rarely autotomise their tails) have noticeably impared locomotory capacity if the counterweighting tail has been recently lost.

The ability to fold the short tail tightly near the body would be an advantage when avoiding predators in short and/or irregularly shaped refuge holes. Such potential refugia were frequently seen in both mallee lignotubers and kunkar limestone.

The swimming capacity of the Marion specimens has already been noted and a vertically compressed tail may improve swimming capacity. Swimming ability would be important if inhabiting burrow systems in soils and lignotubers of non-draining kunkar depressions.

3. *Colour and pattern*

The more or less uniform patterning on the upper and lateral neck, body, and proximal third of the tail is of irregularly oriented and scattered linear dark brown blotches tending to cover up to five scales each with 80% of these surfaces being a uniform grey brown ground colour.

A strikingly similar pattern occurs in the undescribed Port Germein *Tiliqua.* The latter species inhabits sampphire *(Arthrocnemum)* flats that are prone to infrequent flooding by rain and very high tides. From its more or less permanent burrow system it forages by day on the ground under sampphire bushes near its burrow. Its back pattern provides excellent camouflage on the sampphire litter.

During the field assessment grey-green fine-leaved chenopodeaceous shrubs of a straggling, tangled procumbent habit were frequently found in association with mallee growing near outcropping kunkar sheeting. The litter mat developed under these bushes is very similar in visual appearance to that in the Port Germein sampphire areas. This observed chenopod litter substrate may be that on and near which *adelaidensis* is active.

The limbs head and distal two-thirds of the tail are unpatterned, pale brown yellow in spirits with three of the specimens (R2229, R8587 & R8589) showing a tendency to a reddish tinge in these parts as noted by Boulenger (1887, p148) in the BM (NH) specimen.

The burrowing Desert Skink *(Egernia inornata)* is similar to *adelaidensis* in that live specimens not only show paling of the extremities (limbs, proximal tail, only the snout) but also match the colour of these members very closely with the colour of their sand substrate (ie. substrate below the organic topmost horizons). I have observed this in specimens from buff, pale and moderately red coloured sands.

T. adelaidensis may have a similar capacity to match extremity colour with that of the subsurface soil. At the Adelaide Plains field sites buff, light brown or reddish sandy soils occurred below the upper shallow organic horizons and above the kunkar limestone sheet.

4. *Finger claws and lamellae.*

The morphology of the third finger (lamellar & claw profile, claw angle, mid-digit lamellar cross section, and subdigital lamellae count) of *adelaidensis* is graphically compared with 8 other species in Table 2. The substrates from which the illustrated specimens were taken are also summarised.

Despite the varied states of flexion-extension of the illustrated third fingers (preservation artefacts) the relative positions of claw and terminal lamellae (supra & subdigital) do not vary. The scales and the claw are more or less rigidly bound together in life (tested during study). The axis of rotation of the terminal

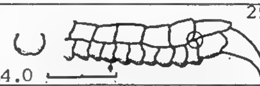
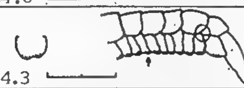
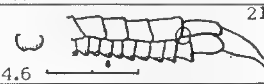
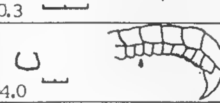
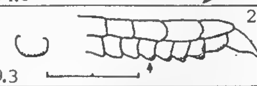
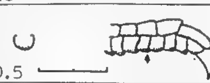
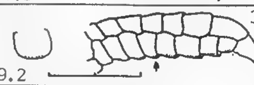
Species no. examined with substr. data	In-life substrate of illustrated specimen	Lamella section, no., lamellae & claw profile, claw angle. scale 2 mm
Egernia whitii n = 3	sandy soil with course fine rubbly fragments, sandstone floaters and outcrops	25  14.0
Egernia multiscutata n = 3	fine shellgrit with fine sand and organic fine mulch	20  14.3
Egernia inornata n = 4	sandy soil of homogeneous fine texture	21  14.6
Tiliqua scincoides n = 12	sandy soil on weathered sandstone & siltstone	41  10.3
Tiliqua gerrardii n = 2	lianes and hollow trees/logs in coastal rainforest on deep mulched course sand	31  14.0
Tiliqua casuarinae n = 4	sallow mulched deep sand	28  9.3
Tiliqua branchialis n = 8	Triodia hummock on compacting sandy loam near dry arid-zone creek	31  9.5
Tiliqua sp Pt Germein n = 6	silt mulched with very fine seaweed fragments, scarce fine shellgrit	33  10.5
Tiliqua adelaidensis SAM R2229	stones (? pile) on grey silty clay-loam	35  9.2

TABLE 2. SUBSTRATE DETAILS AND THIRD FINGER MORPHOLOGY. Front lamella section at mid-digit. Claw and lamellae profile and mean subdigital lamellae number, arrow indicates mid-digit. Stippling indicates subdigital callose tissue distribution. Centres of circles indicate axes of claw segment rotation. Claw angle (in degrees) measured from claw tip to contact points with upper and lower lamellae thus:

phalanx passes through the finger very close to the lower proximal visible corner of the last supradigital lamella (see circles on some finger profiles, Table 2).

Generic difference evident in Table 2 are: 1) usually a greater number of subdigital lamellae in *Egernia* than in *Tiliqua* 2) proportionally longer and pointier claws in *Egernia* 3) a distinctly double ridged callosing on mid-digit and other proximal subdigital lamellae in *Egernia* (present but only feebly developed in *T. scincoides*).

The Bluetongue *(T. scincoides)* is almost exclusively terrestrial (I have on rare occasions seen them climb to 2 metres into non-fruiting partially sloping fruit trees and in dense passionfruit vines). Its short claws, blunt claw angle (41°) and strongly developed subdigital callosing correlate with its terrestrial habits.

The Pink-tongued Skink *(T. gerrardii)* in contrast is adapted for climbing in and on vegetation, trees, vines etc. It has strongly recurved claws, relatively sharp claw angle (31°), and relatively flat pad-like subdigital lamellae section with callosing restricted to the more distal ones.

The finger and lamella section in *T. casuarinae* and *branchialis* is somewhat flattened (see Table 2) and their claw angles are sharp (28° & 31°) correlating with homogeneous sandy soils *(E. inornata, T. casuarinae* and *branchialis)* is distinctly concentrated in the accute angle already pointed out. Inhabitants of heterogeneous textured soils tend to have a narrow full length lamellar distribution of callose tissue (see profiles Table 2).

Applying these habitat correlations to *adelaidensis:* claw angle (35°) suggests a slightly more heterogeneous and/or hard substrate than that experienced by the undescribed Port Germein *Tiliqua* (33°); lamella section is pad-like (but not as developed as in *gerrardii*) with callosing similarly but more extensively developed than in *gerrardii*. This can be taken to suggest that *adelaidensis* inhabits a heterogeneous soil substrate and also an "arboreal" situation eg. mallee stump and lignotuber hollows; the unrounded subaccute angled distal lamellae and the distribution of callose tissue (profile, Table 2) suggests *adelaidensis* inhabits a slightly heterogeneous soil with a low concentration of very fine particles.

Specimen R2229 (from Dry Creek) still has small amounts of silty mud adhering to some claws, toes and fingers as well as in the irregular grooves of the head rugosities. This is best seen following partial surface drying of fluids.

Specimen 4307B (held in captivity) has distinct small subdigital lesions with adhering fine white sand.

Specimen R2228 (from Burra) has a red sandy soil residue in a left mid palmar lesion.

5. *Eyes, peri-ocular condition and peritoneum*

The eyes of *adelaidensis* are noticeably small and distinctly recessed in the orbit so that a hard overhanging supraciliary ridge protects the eye ball and even the eyelids (see Fig. 2). Similar recessing of the eye occurs in the Pinktongue *(T. gerrardii)*, the Shingleback *(T. rugosa)* and the Bluetongue *(T. scincoides)* and these all use their heads as "fit" gauges. On the other hand the eyes of preserved Sheoak Skinks *(T. casuarinae)*, and *T. branchialis* are relatively protruded and the supraocular/supraciliary region is flexible and not overhanging. The latter species inhabit yielding obstacles (grass, litter, hummock bushes).

One specimen of a *branchialis*-like animal from 15 km east of South Australian-Western Australian border (Great Australia Bight) in the Australian Museum (AM Herp 27632) was taken from a burrow under a limestone slab near the cliff edge. Its eyes are noticeably smaller and more recessed than *branchialis* from *Triodia* hummocks. The head's cross sectional area is greater than any part of the body and the supraocular/supraciliary region is distinctly pitted with what appear to be healed fine point impact and abrasion scars.

Eye protection during rapid head probing of possible escape paths into or between hard unyielding obstacles would be of importance to *adelaidensis*.

S A M Reg'n No. SVL:T	Locality and Collectn Date	Identifiable Gut Contents (w) = whole prey item, otherwise determined from fragments only.	Sex	Tailbase ridges *	Reproductive Condition (gonads) L = Left, R = Right, diam = diameter, max = maximum, all dimensions in mm.
R2227 74:46	Central South Austr. no date	partly evicerated	♂	+	L:8.1 long x 4.0 diam dense packed tubules; vas deferens thick white and tightly coiled 0.30 diam . R: removed
R8588 77:52		partly evicerated	♂	+	L:8.4 long x 4.2 diam; R:9.8 long x 5.0 diam — as for R2227
R8589 85:59		wholly evicerated	?	+	wholly evicerated
R2228 58:37	North Burra SA no date	2 ants, grasshopper, spider, soft plant material - ?chenopod	♂	+	L:3.6 long x 1.0 diam; R:4.1 long x 1.3 diam — testicular tubules & vas deferentia microscopic, clear
R8587 88:44		cockroach, beetle, ant, cricket, seed & anther base of *Dianella*, grass awn, 3 flat grits (?shale) to 1.5 mm diameter.	♂	+	L:5.2 long x 1.6 diam; R:6.1 long x 2.0 diam — as for R2228
R2229 94:53	Dry Creek SA 15.iv.1899	small cockroach (w)	♀	-	L: 8 follicles, to max 2.8 diam; R: 9 follicles, to max 2.6 diam
R4307 B 97:55	Marion SA mid Oct. 1959	Held & fed in captivity: *Hemiergis* tail, sand grains, fine shellgrit.	♀	-	L: 5 follicles, to max 2.2 diam; R: 8 follicles, to max 1.8 diam

TABLE 3. GUT CONTENTS AND REPRODUCTIVE CONDITION OF 7 *Tiliqua adelaidensis* SPECIMENS.

SVL = Snout-vent length, T = Tail length (in mm)

* Tailbase ridges are two short broad ventro-lateral ridges extending backward from the vent margin for 6 to 10 overlying scales.

The pupil in *adelaidensis* is round and the peritoneal lining is distinctly black: both indicate diurnal surface activity.

DIET

Available gut contents are summarised in Table 3. From the meagre data *adelaidensis* is an unspecialised feeder taking mainly invertebrates, unlike its larger relatives the Bluetongue and the Shingleback which are omnivores tending towards herbivory. The presence of a cockroach in the diet could indicate a feeding strategy in which palatable invertebrates are taken after they enter the lizard burrow. The prey items observed are most frequently encountered in litter, on soil and also in low bushes.

The ingestion of plant material may have been inadvertant: the two specimens with plant material also have the greatest diversity and quantity of gut contents.

REPRODUCTION

The available reproductive data are summarised in Table 3.

The obvious reproductive capacity contra-indicates one popular hypothesis that *adelaidensis* is a hybrid from two larger *Tiliqua* ssp. All related hybrids known to me i.e. *T. scincoides* x *T. nigrolutea, T. scincoides* x *T. rugosa,* and *Egernia stokesii* x *E. hosmeri* are intermediate in form between the parents. I have not seen a *T. scincoides* x *T. occipitalis* hybrid (despite attempts over three years to breed them) but it is most unlikely that it would be as markedly different from either parent as *adelaidensis* actually is.

The tiliquine skinks give birth to live young. A specimen of the closely related undescribed Port Germein *Tiliqua* gave birth to two young on 9 February 1982 (SV 42, 41 Tail 22, 25 mm Mass 1.19, 1.28 gm respectively).

A similar reproductive strategy could be expected in *adelaidensis.*

SYNTHESIS

The aspects of the natural history of *adelaidensis* reported and deduced above are concisely summarised in the ABSTRACT.

REASSESSMENT OF RECORDED LOCALITIES

Buchsfelde: The title of Peters' (1863) paper is "Hr. W. Peters gab eine Ubersicht der von Hrn. Richard Schomburgk an das zoologische Museum eingesandten Amphibien, aus Buchsfelde bei Adelaide in Sudaustralien" [Mr. W. Peters gave a Summary of Amphibians sent to the zoological Museum by Mr. Richard Schomburgk from Buchsfelde near Adelaide in South Australia].

Clearly Buchsfelde is the dispatch address only. The Buchsfelde area is noticeably devoid of stones of any kind and the soil is a distinctly adherent alluvial sandy loam. Sandy stony terrain with natural vegetation would have been extensive in the area between 5 and 17 km to the northwest of Buchsfelde (Wards Belt to Reeves Plains) in the 1860's. Today it still contains a few remnant mallee stands on sandy soils with many kunkar sheet outcroppings in small quarries, stone reserves and the lower slopes of some dunes.

In view of the veagueness of many published localities in the 1800's (eg. "South Australia") Buchsfelde as a locality is rather precise.

Adelaide: The British Museum specimens can be attributed to Schomburgk (see above) and Adelaide was a locality approximation.

Central South Australia: discussed previously.

Dry Creek: The railway station is a major shunting yard and handles stock and non-perishables. It is built on a silty alluvial plain at the upper edge of extensive sampphire flats and does not naturally have any surface stones. In earlier times many railway stations were also depots for building materials that had to be brought from the country (eg. timber, kunkar limestone) and for firewood (especially mallee roots). Such firewood dumps and dealers still operate today at Blackwood, Mitcham and North Adelaide Stations. There is strong possibility the Dry Creek specimen was a stow-away in a mallee lignotuber or cavity in a limestone block.

North Burra: Mr. Trueman lived in North Burra in 1945 and moved into a farm house near the Copperhouse School in early 1946. This locality is most likely a despatch point.

Marion: The occurrence of *adelaidensis* as late as 1959 in what was at the time mostly market gardens and vineyards is baffling. The natural substrate of the area is a brown loam without any outcropping rock. The old shed (an outbuilding of a large rural type home) may have had firewood stored in or near it. The stowaway hypothesis suggests itself to explain the two specimens from Marion. The female's reproductive condition (SAM R 4370B) indicates that the species may have bred there and that the two specimens may be descendants.

CONSERVATION STATUS

About 2,500 field man hours have been spent specifically searching for live *adelaidensis* over the past 30 years (F.J. Mitchell, A. Fischer, F. Parker, B. Miller, S.A. Herpetology Group and self). In addition, frequent individual and society field trips have been made on the Adelaide Plain and to other nearby mallee and limestone type habitats. Further specimens of *adelaidensis* could reasonably have been expected with such effort.

1) *Habitat change.*

The undescribed *Tiliqua* from Pt Germein relies on a high humidity microclimate in what must be considered marginal habitat for reptiles. The cave-inhabiting form of *T. branchialis* from Madura W.A. (Storr 1976) also utilises a high humidity micro habitat. The related small tiliquine skinks all occur in mesic microhabitats, and tend to have "patchily" distributed populations.

It is probable that *adelaidensis* was also experiencing "ecological brinksmanship" even at the time of European settlement. The extensive clearing of mallee scrub and stone gathering for farm land, the extraction of limestone for building, and the breaking up and mobilisation of the pristine soil surface (crustose with ephemeral growths as can still be seen in rarely-grazed scrub paddock corners) all contributed to habitat modification and an increased aridity (dryness) at ground level. Deep mobile sand (as is now very abundant around remaining outcrops and in mallee remnants) would be a hindrance to burrowing and rapid locomotion by the small and relatively short-limbed *adelaidensis.*

2) *Predation and Competition.*

Predation by and competition with the introduced House Mouse *(Mus musculus)* may also be involved in the lizards' decline. Mice plagues occur irregularly every five to fifteen years (either local or widespread) on the grain farmed Adelaide Plain. At plague times mice are known to eat almost anything; boots, small dead animals and garden plants. They swarm in the thousands in sheds, stone piles and mallee scrub remnants (B. Redford 1980 pers. comm.).

A cool lizard in its burrow, cavity or shelter hollow would be no match for the large numbers of hungry mice that could easily extract and eat it. In grain growing areas where mice are common, similar-sized reptiles are relatively uncommon compared with large inviolate forms and small size reptiles (which can shelter in small enough sites that are inaccessible to mice). The abundance of the Shingleback *(T. rugosa)* in grain growing areas of South Australian may be partly attributed to their tough body covering which helps to ward off gnawing mice.

I have seen nine Robust Comb-eared Skinks *(Ctenotus robustus)* on Yorke Peninsula with tail stumps which were obviously chewed in at least two places. It is difficult to find large individuals of this species, and there is a high incidence of tail stumps only that are barely or only partly regenerated.

Mice, *C. robustus* and *adelaidensis* are all of a similar size. Whitaker (1973) documents the severe impact of the Polynesian Rat *(Rattus exulans)* on lizards occurring on offshore islands of New Zealand. Newman (this issue) documents its apparently devastating effect on tuatara populations. The inferred habitat of

adelaidensis could be likened to islands, especially once land clearing was advanced.

3). *Introduced poisonous prey.*

It may be that introduced prey species were poisonous to *adelaidensis.* Small introduced snails (*Helicella neglecta, H. virgata, Cochlicella acuta, C. ventrosa,* and *Theba pisana* — see Laws 1973) were collected and ten to fifteen of each species were lightly crushed and force-fed to 5 juvenile Bluetongues (one lizard, one snail type): they were not unpalatable and no ill effects were observed. Long-term feeding may have a different outcome.

The introduced tenebrionid beetle *(Blaps polychestra)* (which has a posterior squirting chemical defence mechanism) is lethal to chickens and mice if eaten and was first noted at Wallaroo in 1930 having since spread onto the Adelaide Plain (see Matthews 1975). Although this beetle is usually too large as a prey item for *adelaidensis* there are occasionally smaller individuals that could be taken by it. The beetles are very common in the stony mallee areas of the Adelaide Plain. A juvenile Bluetongue was offered and took a small *Blaps* head first. After the initial 3 crush bites it was hastily rejected and a straw-brown acrid fluid exuded from the insect. The lizard salivated noticeably and its eyes became very watery. It blinked frequently and then tended to keep its eyes closed. After twelve hours the lizard appeared fully recovered.

Blaps beetles are nocturnal: they crowd into burrows, stone and mallee root cavities and wood hollows during daylight hours. Exist and entry by a diurnal lizard would be difficult and possibly hazardous (squirting chemical defence).

4). *Further work.*

Before *adelaidensis* is given the dubious honour of extinction an intensive search should be made of the mallee areas east of the Mount Lofty Ranges and also the scrub remnants on Yorke Peninsula (particularly mid and upper remnants).

However the failure to locate further specimens despite considerable field work, the highly modified habit, and introduced predators and competitors support the view that the species is endangered. It is proposed that *adelaidensis* be added to the IUCN Red Data Book.

ACKNOWLEDGEMENTS

I sincerely thank Mr A. Fischer and Mr A. Trueman for the time and information they gave in recalling their experiences. The following kindly provided information or access to same: Mr Clift, Mr Glover (SAM), Ms C. Houston, Dr Jessup (S.A. Herbarium), Mr P. Jones (SAM), Mr M. Medwell (Geographical Names Board of South Australia), Mr G. Mengden, Mrs A. Mitchell, Messrs A. Stimson & C. McCarthy (BM (NH)), Dr G. Peters (UHZ), Dr G. Pretty (SAM), Mr B. Redford, South Australian Archives, Mr G. Shea and Mr M. Tyler. For access to specimens in their care I am grateful to Mr P. Aitken and Dr T. Schwaner of the South Australian Museum and Drs H. Cogger & A. Greer of the Australian Museum. Permission to conduct herpetological field work in South Australia was granted by the S.A. National Parks & Wildlife Service. Thanks to Geoff and Jan Coombe and Greg Johnston who accompanied and endured at times difficult field work. To Helen Ehmann who spent many hours with me patiently deciphering and translating difficult Krefft correspondence I am most grateful. Thanks to my wife Therese for her patience and endurance while I searched for *adelaidensis* and clues.

Mrs Charlotte Tawil kindly typed the manuscript. The CSIRO Science and Industry Endowment Fund supported this study with microscope equipment. Thanks to Dr Harold Cogger for his helpful criticisms of the manuscript.

REFERENCES

ANONYMOUS (1968): *The Reader's Digest Complete Atlas of Australia.* 1st Edition. Reader's Digest Association, Sydney.

BOULENGER, G.A. (1887): *Catalogue of the lizards in the British Museum (Natural History).* Vol. 3. London.

COGGER, H.G. (1979): *Reptiles and amphibians of Australia.* Reed. Sydney.

GUNTHER, A. (1867): Additions to the knowledge of Australian reptiles and fishes. *Ann. Mag. Nat. Hist.* 3rd series *20*:45-68.

HALE, H.M. (1956): The first hundred years of the museum — 1856-1956. *Rec. S. Aust. Mus. 12.*

LAWS, H.M. (1973): Terrestrial Molluscs Chapt. 4 in *Yorke Peninsula — a natural history.* (Ed) D. Corbett Dept. of Adult Education, University of Adelaide.

MATTHEWS, E.G. (1975): The Mediterranean beetle *Blaps polychestra* Forskal in South Australia (Tenebrionidae). *South Australian Naturalist 49* (3): 35-39.

MITCHELL, F.J. (1950): The scincid genera *Egernia* and *Tiliqua* (Lacertilia). *Rec. S. Aust. Mus. 9* (3): 275-308.

PETERS, W. (1863): *Mber. Akad. Wiss. Berlin 1863:* 228-236.

STORR, G.M. (1976): The genus *Omolepida* (Lacertilia, Scincidae) in Western Australia. *Rec. West. Aust. Mus. 4* (2): 163-170

WAITE, E.R. (1929): *Reptiles and Amphibians of South Australia.* British Science Guild Handbook. Adelaide.

WHITAKER, A.H. (1973): Lizard populations with and without Polynesian Rats, *Rattus exulans* (Peale). *Proceedings of the New Zealand Ecological Society 20*: 121-130.

WHITLEY, G.P. (1971): George Masters, Naturalist. *Proc. Roy. Zool. Soc. N.S.Wales 1969-70:* 25-32.

A SHORT GUIDE TO GETTING MORE HERPETOLOGICAL EDUCATION INTO SCHOOLS.

Danny Wotherspoon, Education Service, Taronga Zoo, Sydney.

There are many possibilities for the contribution of articles to educational journals by members of our Societies. The constitutions of our societies have clauses which give Education as one reason for our existence. The following comments illustrate means by which individual herpetologists can realise the goal of public understanding of the nature and role of our herpetofauna.

There are two main areas of useful activity open to us: publication, and animal display within a school.

Publications in Educational Journals.

There are many levels of information relevant to teachers' needs. These range from Primary school teachers with no herpetological background but a desire to illustrate some natural history, to senior high school Biology teachers.

Appropriate articles may be along the following lines:

a) *Tadpoles.* "Why do our classroom tadpoles nearly always die when they become frogs?" Some guidance is needed here for the ongoing maintenance of the species most commonly kept in each city, town or region. Elaboration may be helpful on the local ecology of the animal, to enable a class to establish conditions suitable for a colony in the school grounds. Use diagrams.

b) *Lizards.* Depending on State wildlife legislation, a local lizard species may be suitable for observation of basking, emergence, territorial, feeding and breeding behaviour. An experienced keeper can put into print the keeping requirements of an easily maintained local species, and detail the observations which can be made. A sample recording method would be helpful. Use diagrams.

c) *Dissection of Road kills.* Write an outline of temporary and longterm preservation methods, with some labelled diagrams of major stages of dissection. Each area will have a species commonly found dead on road. Comment on the likely state of stomach contents.

d) Conservation issues of local and national importance. For example, some species may be enhanced, others decline, due to agricultural or urban development. Which species are in the habitat types so affected in your area? See note on Lizard rescue work by N.Z.H.S. (Herpetofauna 13(2):32).

Publications (*)

a) Australian Science Teachers' Journal (A.S.T.J.)
"Techniques for Teachers" Section.
c/- Mr P.S. Manchester,
Alanvale Community College,
Locked Bag No. 1,
Newnham, Tasmania, 7250.

An academic journal, with educational and practical sections.

b) "Biology in Action", a newspaper style presentation, with snippets of scientific news. It is aimed at senior high school biology students. Write to the Publications Officer, Australian Academy of Science, P.O. Box 783, Canberra City, A.C.T., 2601.

c) Science Teachers' Association (S.T.A.) News.
(Similar to A.S.T.J.) Only in N.S.W.
"Science Education News."
C/- Mr T. Rozga,
Sydney Technical High School,
Forest Road,
Bexley, 2207, N.S.W.

d) "Education", newspaper of the N.S.W. Teachers' Federation, 300 Sussex St., Sydney, 2000. Circulated to all schools, it is suitable for advertising your services to every kind of teacher. There are local equivalents where you are.

(*) All journals have editorial requirements similar to Herpetofauna.

Animal Display within Schools.

As a herpetologist you can easily establish a working relationship with the schools where you live to further the educational aims of our societies. Some ideas to start with are:

a) Offer to set up and maintain a live display. Staff and students may be taught to do the same.

b) A school excursion to a local natural area could include a herpetological segment, with your assistance.

c) The Parents and Citizens Association in the school may provide finance for a project such as landscaping and tree planting suitable for local fauna.

Conclusion

Remember that teachers are people too, and may have a reluctance to new ideas. Your ability to gently guide them into easily attainable skills and attitudes is an essential foundation for the aims of our Societies. Start small and let their interest grow. If we "force feed" them on snakes, they may reject the teaching opportunities of our herpetological fauna for ever.

HERPETOFAUNA

Vol. 14 No 2 1983

SOME OBSERVATIONS ON THE REPRODUCTIVE BIOLOGY OF THE COMMON SCALY-FOOT PYGOPUS LEPIDOPODUS

Mark Fitzgerald P.O. Box 237, Mullumbimby NSW 2482

Very little is known of the biology of the Australian family Pygopodidae. In particular the reproductive biology is poorly known. Cogger (1979) states that "All pygopodid lizards are oviparous and, according to Kluge, all species lay two elongate parchment-shelled eggs in a clutch." This mode of reproduction, combined with the vocal abilities of these lizards, points to a relationship with the geckoes.

In the summer of 1981-1982 I had the opportunity to examine two clutches of eggs of *P. lepidopodus,* and present the findings below.

P. lepidopodus is a relatively common lizard in the New South Wales/Queensland coastal border region. It is found in a variety of habitats from littoral heath through adjacent *Melaleuca* swamps into both open and closed forest in the coastal ranges. I have not found it in pasture, but it is found in scrubby regrowth and lantana. *P. lepidopodus* from this area are reddish brown dorsally and adults are commonly 60cm in total length. *P. lepidopodus* is nocturnal during summer but is encountered during the day in spring, and late summer/autumn.

A gravid female *P. lepidopodus*, approximately 55cm. in total length was collected during the second week in December, 1981 on a road in the Billinudgel area at 10p.m. The area is low lying *Melaleuca* and reed swamp. On the 15th of December this lizard deposited two capsule-shaped eggs. One egg was preserved for embryological study and this measured 38mm x 16mm. The remaining egg was placed in damp peat moss in a clean plastic margarine container and kept at slightly higher than ambient temperatures. The range during incubation was approximately 22°-32°C. and this egg hatched 24th February after 71 days incubation. Within an hour of emergence this lizard displayed "snake mimicry" in response to any disturbance. At emergence this lizard was approximately 160mm in length and coloured identically to the adult.

A second large reddish *P. lepidopodus* was seen in January, 1982 on a steep north-east facing slope in coastal foothills at Mullumbimby Creek. This location is old banana ground where bracken, wattle and stunted lantana grow on a stony yellow clay. The area was slashed by hand preparatory to planting bananas and it was in this cleared zone that the lizard was seen. Due to the difficult terrain this lizard was not collected, however, on 7th February, 1982 two eggs were found in loose soil at the edge of a hole dug in the hillside for planting bananas. Reptiles in this area often utilise man-made disturbances to the soil for oviposition, especially where the soil is of a tight or dense structure. From other banana plant-

ing holes I have recovered eggs of the Eastern water dragon *Physignathus lesueurii,* Bearded dragon *Amphibolurus barbatus* and the skink *Lampropholis delicata.* Crumbling soil at the edge of road embankments has yielded *P. lesueurii* eggs as well as those of the yellow-faced whip snake *Demansia psammophis.* The loose soil in both of these sites holds both the heat and moisture necessary for successful development.

The two eggs were gathered with soil at the site and were placed in a clean plastic margarine container. Slightly higher temperatures prevailed during incubation of this clutch: a range of 24° - 33°C was noted and the eggs hatched on March 20th after 41 days development. It is assumed that this represents only part of the time required for development, the eggs probably containing partly grown embryos when found. These lizards resembled adult *P. lepidopodus* in colour and their emergence was synchronous with the second hatching of the skink *Lampropholis delicata,* an abundant potential prey. They were sent to the Zoology Department of the University of Sydney for use in a study on feeding in the family Pygopodidae and they have since eaten mealworms. On 15th April, 1982 these lizards were weighed and measured.

Weight (grams)	Snout-vent length (mm)	Tail-length (mm)	Total (mm)
3.05	81	120	201
3.54	85	134	219

Thanks are due to Dr. Richard Shine and to Fred Patchell for measuring the young.

Reference

COGGER, H.G. (1979) Reptiles and Amphibians of Australia. A.H. & A.W. Reed, Sydney.

SOME OBSERVATIONS ON VOCALIZATION AND THE USE OF LIMB FLAPS IN THE PYGOPODID LIZARD, DELMA INORNATA KLUGE.

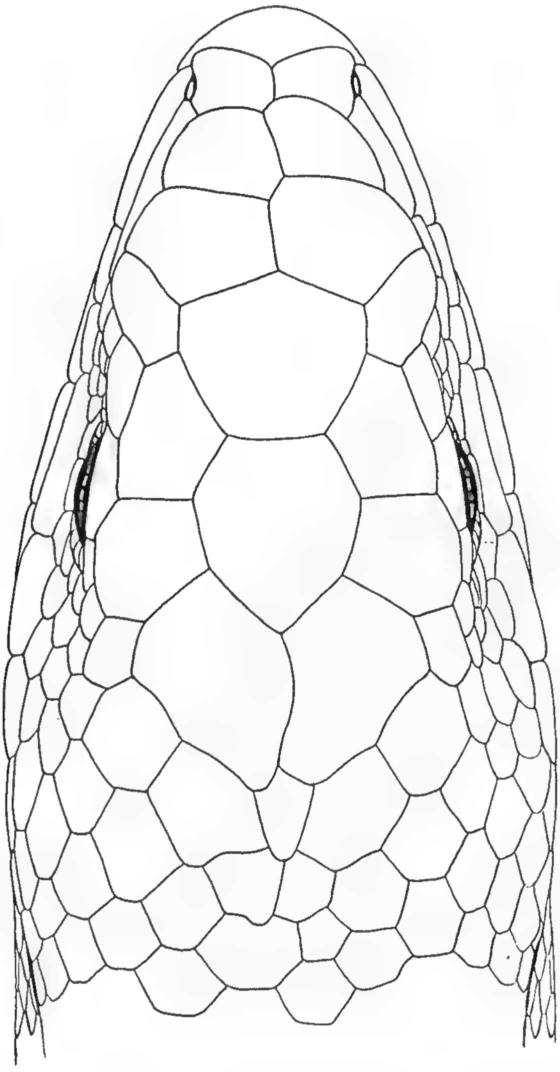
Mr T. Annable, Riverina College of Advanced Education, P.O. Box 588, Wagga Wagga, NSW 2650

The various noises made by certain reptiles are quite well known, particularly the hissing type noises made by snakes, crocodiles, tortoises and many of the larger lizards. Vocalization among the marine turtles is perhaps less well known (see Gans and Tinkle, chap. 6), however the controlled, resonant vocalization found among the geckos (family Gekkonidae) is familiar to many especially those who live in tropical areas where the more vocal species seem to be most abundant. While some geckos seldom if ever vocalize, others may do so almost incessantly when active, some species having a vocabulary of several different sounds.

Most sounds produced by reptiles are respiratory in origin. They are usually produced by the forcible expulsion of air through the glottis and if the glottis muscles are tensed then the overlying mucous membrane may be induced to vibrate producing a resonant note rather than a mere hiss. The significance of vocalization in reptiles is not always apparent but is frequently linked with behavioural responses such as alarm, territoriality, aggression, warning, courting and location of conspecifics.

Among the Flap-footed lizards (family Pygopodidae) it is known that some species are capable of controlled resonant vocalization. Burton's legless lizard (*Lialis burtonis* Gray) and the Striped legless lizard (*Delma impar* Fischer) are both recorded as producing squeaks (see Jenkins and Bartell p. 113 and 118). However,

I was unaware of these references when collecting reptiles in grassed hilly country near Jugiong N.S.W. in late summer when I captured two subadult specimens of the flap-footed lizard, *Delma inornata* measuring 70 mm and 84 mm snout-vent lengths. The smaller specimen immediately emitted a series of long squeaks. Both specimens were kept together in a terrarium and observed intermittently over a period of several weeks. On several occasions one, and possibly both,



Head scalation of **Delma inornata** (Wagga Wagga). This species is found accross Victoria, central NSW and SE Queensland.

specimens were heard to emit short squeaks of about 0.5 s duration. This sound could easily be heard at a distance of several metres and would obviously be useful to a species which tends to be solitary and to live in long grass where visibility is limited. Occasionally these squeaks were repeated although it was not certain whether the second sound was an answering call or not. During the periods when vocalization was occurring the lizards were actively moving about and were within sight of each other but did not appear to be engaged in any other specialized activity. Of numerous specimens observed only one other, a juvenile (54 mm snout-vent length) was heard to vocalize with repeated squawks of a lower pitch than the subadults.

The significance of these observations remains in doubt although it is interesting to note that in spite of the vastly different external morphology of the two reptile families, the Pygopodidae and the Gekkonidae are in fact quite closely related. The infraorder Gekkota comprises these two families plus the Dibamidae family (legless, burrowing lizards about which very little is known). The major reason for deciding this relationship is based on the similarity of certain skeletal structures, however there are several other similarities, (See Gruber 1975, Kluge 1974, Waite 1929), and the fact that pygopodids vocalize is perhaps another indication of their close relationship to the gekkonids.

Interestingly there is one species of gecko which I have not heard vocalize and that is the Marbled Gecko (*Phyllodactylus marmoratus*) which is very common in the Wagga Wagga area, while several other gecko species found in this area have been observed to vocalize.

As regards vocalizing in other lizards I have found that a number of other species may emit some kind of squeak on capture including the following skinks.

Ctenotus robustus (Wagga Wagga)
Egernia striolata (Wagga Wagga)
Egernia cunninghami (Adelong and Yaven Creek)
Lampropholis mustelina (Armidale)
Sphenomorphus quoyii (Gosford)
Sphenomorphus tympanum (Adelong and Yaven Creek)

Another interesting observation is that *Delma inornata* do use their limb flaps in locomotion (contrary to Gruber, p173), and possibly also in mating. On several occasions specimens were observed to use their flaps quite vigorously when traversing rough terrain or when climbing in grass tussocks in pursuit of small moths (a favourite food item) and other insects. They were also observed to extend their flaps when alarmed, usually together but occasionally separately and to an angle of about 80° or 90° to the body. The length of the limb flaps is variable from about two and a half to four per cent of snout-vent length with three to five scales along the upper edge.

References

GANS, C. and D.W. TINKLE (Eds) (1977): Biology of the Reptilia, Vol. 7. Academic Press, London.

GRUBER, U. (1975): The Geckos and their Relatives in Grzimek's Animal Life Encyclopedia. Vol. 6. Reptiles. Van Nostrand Reinhold, New York.

JENKINS, R. and R. BARTELL (1980): A Field Guide to Reptiles of the Australian High Country. Inkata Press, Melbourne.

KLUGE, A.G. (1974): A taxonomic revision of the lizard family Pygopodidae, Misc. Publ. Mus. Zool. Univ. Michigan, 147: 1-221.

WAITE, E.R. (1929): The Reptiles and Amphibians of South Australia. Adelaide, British Science Guild.

OBSERVATIONS ON DEVELOPMENT
OF THE
FIJIAN TREE FROG, PLATYMANTIS VITIENSIS

John R. H. Gibbons and Michael L. Guinea
University of the South Pacific
Suva, Fiji.

Introduction

The Fiji Islands contain two endemic amphibians, the tree frog *Platymantis (= Cornufer) vitiensis* and the ground frog *P. vitianus.* Previous publications have been limited to distribution and life history data (Gorham, 1965, 1968; Pernetta and Goldman, 1977). Both species lack a free-living tadpole stage. In January-March 1981, several clutches of *P. vitiensis* eggs were recorded and a number of eggs were removed to the laboratory where the following observations on development were made. The clutches were located close to a small stream (18°5'S, 178°30'E) in the Wailoku drainage area 10km north of Suva, Viti Levu. The stream flows beneath a closed canopy forest which limits light and wind penetration and maintains a high relative humidity. The eggs were confined to the axils of *Pandanus* sp. growing in the vicinity of the stream. The leaves are used at night by adult and juveniles as vantage points for feeding and courtship (P.A. Ryan, unpublished). By day they hide within the axils, amongst several centimetres of humus from the canopy trees.

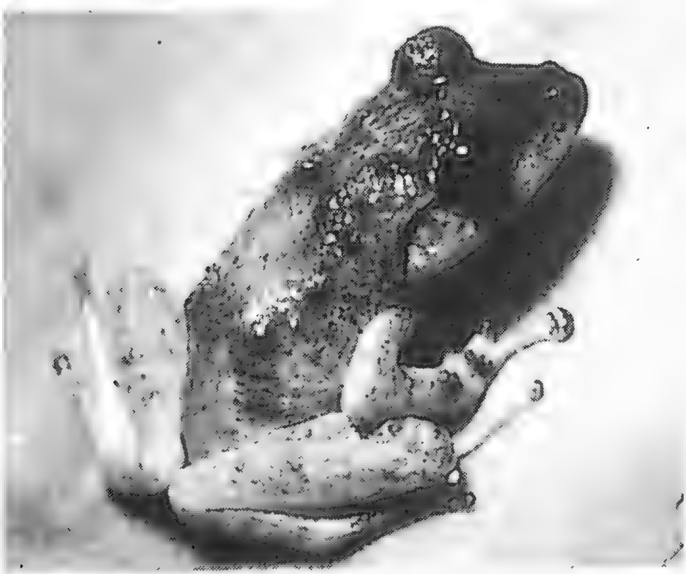


Figure 7 Adult specimen of *Platymantis vitiensis.*

Methods

Two eggs from each clutch found on 29-30 January were carefully removed, placed in a small, moist polythene bag and taken to Suva. During the next ten days photographs were taken almost daily using a Konica FS1 camera with a 55mm macro lens and extension tubes so that a 2:1 ratio magnification was

achieved. A flash mounted on the camera plus a slave unit held on the opposite side of the polythene bag from the camera enabled us to use F stops of 16 and 22, and thus obtain considerable depth of field. During the time they were not being examined or photographed, the eggs were kept in strongly shaded or dark conditions to prevent overheating. For a few days all four embryos survived, but perhaps because of over-handling and excessive heating, especially during photography, one of the two more advanced embryos died after five days and the other followed two days later. Both appeared close to hatching.

In early March four more eggs were collected and placed in an air-conditioned room (22°C). These eggs were held in similar moist polythene bags as used previously, but on this occasion leaf litter and detritus from the axils of *Pandanus* were added, and the embryos survived.

Results

The first clutch of eggs was located on the night of 29 January (austral summer). Several eggs were photographed and collected the following day, when a second clutch in the more advanced stage of development was located 30m further upstream. On 2nd March a third clutch was located in the same area. The clutch sizes were 17, 18 (3 dead) and 14 respectively. Clutch temperature was 26°C. Clutch height above ground level was 0.5m, 0.2m, 1.1m respectively; all were located within 10m of the stream. Egg diameter was 8-9mm with a 1mm thick, transparent gelatinous coat. Freshly laid eggs looked like small marbles with white yolk centres. Each was attached to its neighbour by a gelatinous thread.

The various stages of development are listed below. We have followed Alcala (1962), who described development in three species of Philippine *Platymantis.* Alcala's scheme included (1) early stages such as cleavage, blastula and gastrula, (2) a limb bud stage, (3) a limb paddle stage, and (4) metamorphosis.

Early Stages

These were not seen. However, one might expect early stages to be similar to those in most other frog species with direct development (e.g. see Tyler, 1976), as is the case for the Philippine *Platymantis.* It is our impression that cleavage, blastula and gastrula stages are relatively brief, occupying less than a week.

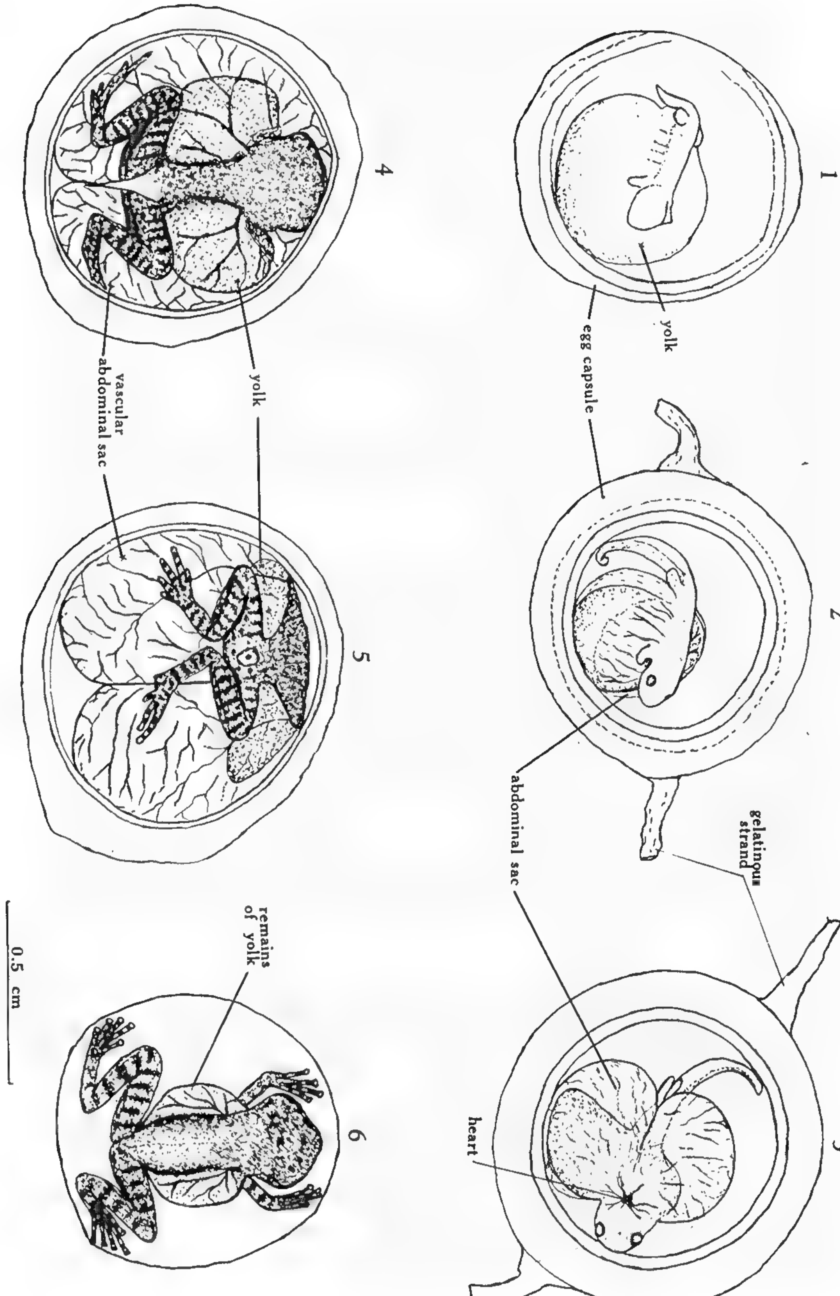
The Limb Bud Stage

The 4-5mm embryo was unpigmented and lay dorsal to the yolk (Fig. 1). This position was maintained by tail movements when the egg was rotated. The head, anterior and posterior limb buds and a thin blade-like tail were visible. The tail underwent rhythmic lateral contractions when stimulated by either movement or strong illumination.

The Limb Paddle Stage

The embryo length increased to about 9mm of which 4mm was tail (Fig. 2). Pigmented eyes were present and the limb buds developed into paddle-like structures with no sign of digits. Blood vessels spread over the yolk were attached to a visibly beating heart below the head in the anterior thoracic region. On either ventral side of the yolk, and attached to the body, was a translucent abdominal sac.

Figures 1-6 Phototracings of direct development in *Platymantis vitiensis.* 1 -limb bud stage; 2,3 - limb paddle stage seen from different orientations; 4,5 - later embryo showing abdominal sacs at maximum size attained; 6 - final stage after rupture of abdominal sacs. For further details on all figures — see text.


1
yolk
egg capsule
2
gelatinous strand
abdominal sac
3
heart
4
yolk
vascular abdominal sac
5
remains of yolk
6
0.5 cm

Metamorphosis

The embryo attained pigmentation and pattern of juvenile frogs (Figs. 4-6). The limbs had webbed digits. The yolk was greatly reduced in size and appeared as two lateral wing-like projections from the ventral abdominal region. The colour of the yolk had changed to yellow and become heavily vascularised. The region below the embryo was now filled with the greatly enlarged abdominal sacs. The membranes of these sacs were heavily vascularised and the contents cloudy. A much reduced tail was still present, though it no longer appeared capable of movement. The hind limbs were well developed and capable of swimming actions. These helped keep the embyro dorsal to the yolk.

Hatching

All four eggs had hatched by early April but the process of hatching was not observed. Some were observed just prior to hatching, when the abdominal sacs had ruptured (Fig. 6), with fluid apparently leaking out of the egg capsule. By this time the tail had been almost completely resorbed, but small bodies of yolk material remained attached to either flank.

The egg capsule appears thin and soft just prior to hatching, and continues to disintegrate following hatching. Field observations of clutches with dead embryos showed that they retained fully intact egg capsules many days after other eggs had hatched. The whole process of development from laying to hatching probably takes between thirty and forty days. Hatching frogs measured 6-7mm SV length and weighed about 0.1g.

Discussion

Our observations of egg development in *Platymantis vitiensis* are strikingly similar to those of Atoda (1950) and Alcala (1962) on congeners. They show a number of features shared with other frog genera exhibiting direct development, including complete loss of larval mouthparts and gills, and early development of limbs (e.g. see Tyler 1976).

An unusual feature of the genus is the development of the very large, thin-walled and highly vascularised sacs from the walls of the abdomen (Alcala, 1962). Alcala has suggested that they have a respiratory function. This seems likely, but in addition they may be involved in waste storage.

Acknowledgements

We thank our colleague Dr P.A. Ryan for introducing us to this frog population, and suggesting that we study the animals during his absence overseas. We gratefully acknowledge M.J. Tyler's and P.A. Ryan's refereeing of the paper, and thank Prem L. Kumar for typing the manuscript.

References

ALCALA, A.A. 1962: Breeding behaviour and early development of frogs of Negros, Philippine Islands. Copeia 1962 (4): 673-726.

ATODA, K. 1950: Metamorphosis of the "non aquatic" frog of the Palau Islands, Western Carolines. Pac. Sci. 4: 202-207.

GORHAM, S.W. 1965: Fiji frogs (with synopses of the genera *Cornufer* and *Platymantis*). Zool. Beitrage 11(3): 381-435.

1968: Fiji frogs: life history data from field work. Zool. Beitrage 14(3): 427-446.

PERNETTA, J.C. and B. GOLDMAN 1977: Botaniviti: the elusive Fijian frogs. Aust. Nat. Hist. 18: 343-437.

TYLER, M.J. 1976: Frogs. Collins, Sydney. 256 pp.

DIET IN A HERPETOFAUNAL COMMUNITY ON THE HAWKESBURY SANDSTONE FORMATION IN THE SYDNEY AREA

GARRY A. WEBB
Forestry Commission of N.S.W.,
P.O. Box 100,
Beecroft. N.S.W. 2119.

Introduction

The distribution of reptiles and amphibians in the Sydney area is relatively well known (Barker and Grigg, 1977; Cogger, 1979). However, dietary studies on these species are relatively few (Crome, 1981; Littlejohn and Martin, 1967; Pengilley, 1971; Rose, 1974).

This study reports on the diet of a herpetofaunal community on the Hawkesbury sandstone formation in the Sydney area.

Study area

The study area was located on vacant crown land (formerly Maroota State forest), near Glenorie (N.S.W.), 50 km northwest of Sydney. The pitfall trapping grid was situated within an area of sandstone complex vegetation (Specht *et al.* 1974) dominated by smooth-barked apple (*Angophora costata*), yellow bloodwood (*Eucalyptus eximia*) and grey gum (*Eucalyptus punctata*) with a low shrub understorey. Soil depth was very shallow with sandstone outcropping occurring commonly within the grid. Fire history for the area was unknown though fire scars on many of the trees suggested that a fire had occurred recently.

Methods

Reptiles and amphibians were sampled by pitfall trapping. Pitfall traps were of various designs and are detailed elsewhere (Webb, 1980). However, all were either five or ten litre plastic buckets sunk flush with the ground, containing 10% formalin as a preservative. Forty eight pitfall traps were installed in a 70 x 50 metre grid with 10 metre spacing. Specimens were removed weekly during continuous sampling over 52 days between September and November, 1979.

The stomachs of specimens were removed, stored in 70% alcohol, and the contents examined later under a microscope. Prey items were normally identified to the ordinal level and the length of each prey item was measured. Where whole prey items were not present identification was usually possible by comparing the remains with other whole animals and the length estimated. Reptile and amphibian specimens were lodged in the Australian Museum. Stomach contents are housed in the Forestry Commission of N.S.W. insect collection.

Results

Forty six reptiles (9 species) and 47 amphibians (4 species) were recorded in the study area by pitfall trapping. Relative densities are given in Table 1. A further two species, *Amphibolurus barbatus* and *Leiolopisma platynota*, were observed on the study grid but not captured in pitfall traps. The frog, *Uperoleia sp.* (44% of total animals) and the skink *Ctenotus taeniolatus* (19.3%) were the most abundant species caught in pitfall traps with all other species occurring in relatively low numbers.

Percentage occurrence of invertebrate prey groups found in the stomachs of reptiles and amphibians examined is given in Table 2. 14% of stomachs were empty or the contents unrecognisable. A wide range of prey (21 groups) were recorded. Ants (30.7%) and termites (18.5%) were the most common prey groups.

Uperoleia sp. took all prey groups except woodlice. Eight prey groups were recorded from the stomachs of *Ctenotus taeniolatus* though relatively few items were recorded in total. The number of stomachs examined for other species was low though it is interesting to note the types and range of prey items taken.

Table 1: Numbers and Percent Composition of Reptiles and Amphibians Caught in Pitfall Traps.

SPECIES	TOTAL	%
Amphibians		
Heleioporus australiacus	3	3.2
Pseudophryne australis	2	2.2
P. bibronii	1	1.1
Uperoleia sp.	41	44.0
Reptiles		
Amphibolurus diemensis	1	1.1
Diplodactylus vittatus	2	2.2
Pygopus lepidopodus	1	1.1
Carlia burnettii	7	7.5
Cryptoblepharus virgatus	7	7.5
Ctenotus taeniolatus	18	19.3
Lampropholis delicata	8	8.6
Sphenomorphus tenuis	1	1.1
Tiliqua scincoides	1	1.1
	93	100.0

Heleioporus australiacus took 9 prey groups including large spiders, centipedes and millipedes. A large number of small mites were found in the stomach of one *Pseudophryne australis*. Similarly a large number of small ants were found in the stomach of *Amphibolurus diemensis*.

Termites were taken only by the three small ground dwelling leptodactylid frogs, *Pseudophryne australis*, *P. bibronii* and *Uperoleia sp.* 32.8% of prey items taken by *Uperoleia sp.* were termites. Pseudoscorpions, mites and collembolans only occurred in the diet of *Pseudophryne australis* and *Uperoleia sp.*

The range of prey size groups taken by reptiles and amphibians is given in Table 3. 88.4% of all prey items were 5 mm in length or less. *Heleioporus australiacus* took the widest range of prey sizes, up to 65 mm. *Uperoleia sp.* took primarily small prey items (◄5 mm). *C. taeniolatus* took mainly small items, up to 20 mm in length.

Discussion

Thirty four species of reptiles and six amphibians regularly inhabit the dry sandstone ridges common in the Sydney area (Cogger, 1979; Webb, pers. obs.). Fifteen species (11 reptiles and 4 amphibians) were recorded during this study.

Table 2. Prey groups (% occurrence) taken by Amphibians and Reptiles

	Heleioporus australiacus	Pseudophryne australis	Pseudorphryne bibronii	Uperoleia so.	Amphibolurus diemensis	Diplodactylus vittatus	Pygopus lipidopodus	Carlia burnettii	Cryptoblepharus virgatus	Ctenotus taeniolatus	Lampropholis delicata	Sphenomorphus tenuis	Tiliqua scincoides	Total
No. animals	3	2	1	41	1	2	1	7	7	18	8	1	1	93
no. empty stomachs	0	0	0	5	0	1	0	0	2	3	2	0	0	13
no. prey items	31	107	2	282	55	2	2	8	4	17	7	1	1	519
Mites		61.7		1.4										13.6
Spiders	16.1	0.0		9.2		50.0	100	50.0	25.0	23.5	57.2			9.2
Pseudoscorpians		0.9		2.5										1.5
Snails				0.7										0.4
Woodlice	3.2													0.2
Cockroaches	3.2			2.1	1.8	50.0		37.5	25.0					2.5
Collembolans		0.9		8.5										4.8
Beetles	19.4			13.0				12.5		23.5	14.3	100		9.6
Earwigs				0.7										0.4
Flies				0.4						11.8				0.6
Webspinners				0.4										0.2
Bugs				3.2					25.0	11.8				2.3
Wasps				0.7					25.0	11.8				1.0
Ants	38.9	18.7		19.3	98.2					5.9	28.5			30.7
Termites		1.9	100	32.8										18.5
Moths				0.4										0.2
Grasshoppers	3.2			0.4						5.9				0.6
Thrips				0.4										0.2
Centipedes	6.4			0.7										0.8
Millipedes	6.4			0.4						5.9			100	1.0
All larvae	3.2			2.8										1.7

Table 3: Percentages of Prey Items In Each Prey Size Class. The average size (snout-vent) length mm of amphibian and reptile species examined is given in brackets.

		PREY SIZE (mm)												
		5	10	15	20	25	30	35	40	45	50	55	60	65
Heleioporus australiacus	(65)	6.4	54.8	12.9	9.7	3.2		3.2	6.4					3.2
Pseudophryne australis	(28)	100												
Pseudophryne bibronii	(26)	100												
Uperoleia sp.	(24)	95.7	2.9	0.7			0.7							
Amphibolurus diemensis	(31)	100												
Diplodactylus vittatus	(59)	50.0			50.0									
Pygopus lepidopodus	(220)				100									
Carlia burnettii	(28)	85.7	14.3											
Cryptoblephorus birgatus	(29)	50.0	50.0											
Ctenotus taeniolatus	(55)	47.4	36.8	10.5	5.3									
Lampropholis delicata	(33)	85.7	14.3											
Sphenomorphus tenuis	(67)		100											
Tiliqua scincoides	(152)			100										
Total		459	37	9	7	1	2	1	2					1
%		88.4	7.1	1.7	1.4	0.2	0.4	0.2	0.4					0.2

Some species may not have been detected because of sampling bias. Pitfall trapping is considered inadequate for sampling the entire community (Longmore and Lee, 1981; Mather, 1979; Webb, 1980), since it tends to oversample small, active surface dwellers relative to more cryptic, arboreal or larger species. Rarer species may also not be detected during short sample periods. Nevertheless, pitfall trapping still remains a simple and effective method of study where time and manpower are limited.

The results of this study tend to support earlier suggestions (Pianka, 1969; Pianka and Pianka, 1976; Crome, 1981; Davidge, 1979), that Australian reptiles and amphibians are generally opportunistic feeders. A wide range of prey groups (21 groups) were used by the Hawkesbury sandstone herpetofaunal community including some large and/or noxious or poisonous prey.

The number of lizards caught in pitfall traps and the number of prey items present in their stumochs was small in this study. However, the range of prey items in the stomachs of *Ctenotus taeniolatus* demonstrates that they are not selective feeders. Crome (1981) suggests that differences in the diet of lizard species are largely the result of differences in microhabitat and foraging behaviour. Data is insufficient to determine if this is true of the Hawkesbury sandstone community though the presence of flies and wasps in the diet of *Ctenotus taeniolatus* is consistent with its active diurnal habit.

Few dietary studies have been carried out on Australian amphibians. These studies, particularly Calaby (1956) and Pengilley (1971), suggest however that some amphibians may have specialized diets. Pengilley (1971) examined the gut contents of 3 species of *Pseudophryne* in south-eastern Australia and found that ants were their principle food source. In this study, mites and termites were numerically more important in the diets of *Pseudophryne australis* and *P. bibronii* though the number of stomachs examined was small.

Termites and ants were important in the diets of the three small ground dwelling Leptodactylid frogs, *Pseudophryne australis, P. bibronii* and *Uperoleia sp.* This is likely to be related to their mode of foraging and the microhabitat in which they occur. Pengilley (1971) suggests that *Pseudophryne* feeds primarily under logs, leaflitter and grass and on prey which is relatively slow moving.

Various authors (Pianka, 1969; Pianka and Pianka, 1976; Smythe, 1968 and others) have suggested that prey size tends to increase with predator size. The majority of prey items in this study were 5 mm or less in length however some large prey were taken by small predator species. *Uperoleia sp.* and *Ctenotus taeniolatus* generally ate smaller prey items whilst *Heleioporus australiacus* took a wide range of large and/or noxious or poisonous prey. A similar range of prey items has been recorded for *H. australiacus* elsewhere (Littlejohn and Martin, 1967; Webb, unpubl. data).

Acknowledgements

I would like to thank Mr R. Eldridge for assistance with identification of prey items. Mr R. Kavanagh critically read the manuscript and Mrs M. Pynt typed the draft.

References

BARKER, J. and G. GRIGG (1977): A Field Guide to Australian Frogs. Rigby, Adelaide.

CALABY, J.H. (1956): The food habits of the frog, *Myobatrachus gouldii* (Gray), West. Aust. Nat. 5:93-96.

COGGER, H.G. (1979): Reptiles and Amphibians of Australia. 2nd Edition. A.H. and A.W. Reed, Sydney.

CROME, B. (1981): The Diet of some ground-layer lizards in three woodlands of the New England Tableland of Australia. Herpetofauna 13:4-11.

DAVIDGE, C. (1979): The herpetofaunal community of a *Banksia* woodland near Perth Western Australia. Unpubl. PhD thesis, Murdock University.

LITTLEJOHN, M.J. and A.A. MARTIN (1967): The rediscovery of *Heleioporùs australiacus* (Shaw) (Anura:Leptodactylidae) in eastern Victoria. Proc. Roy. Soc. Vict. 80:31-35.
LONGMORE, R. and P. LEE (1981): Some observations on techniques for assessing the effects of fire on reptile populations in Sturt National Park. Aust. J. Herp. 1:17-22.
MATHER, P.B. (1979): An examination of the reptile fauna of Wyperfeld National Park using pitfall trapping. Vict. Nat. 96:98-101.
PENGILLEY, R.K. (1971): The food of some Australian anurans (Amphibia) J. Zool. (Lond.) 163: 93-103.
PIANKA, E.R. (1969): Sympatry of Desert Lizards *(Ctenotus)* in Western Australia. Ecology 50:1012-1030.
PIANKA, E.R. and H.D. PIANKA (1976): Comparative ecology of twelve species of nocturnal lizards (Gekkonidae) in Western Australian desert. Copeia 1976;125-142.
ROSE, A. BARCLAY (1974): Gut contents of some amphibians and Reptiles. Herpetofauna 7: 4-8.
SMYTH, M. (1968): The distribution and life history of the skink. *Hemiergis peronii* (Fitzinger), Trans. Roy. Soc. S. Aust. 93:51-58.
SPECHT, R.L., E.M. ROE and V.H. BOUGHTON (1974): Conservation of major plant communities in Australia. Aust. J. Bot. Supyl. series No. 7.
WEBB, G.A. (1980): A preliminary investigation of techniques for sampling herpetofaunal communities. For Comm. NSW unpubl. report pp 1-14.

LETTER TO THE EDITOR

Varanus tristis orientalis

Dear sir,

Would you be kind enough to defuse a bomb-or rather help me defuse one. An error of mine which is in print in "Around Mount Isa" should be corrected so that it does not become perpetuated.

I referred to the trees most favoured by *Varanus tristis orientalis* of the area as the Coolibah and the Snappy Gum. The first name is sometimes used locally for the Western Grey Box, but actually they are two different trees. The Coolibah apparently is not in the area at all. Unfortunately "Snappy Gum" got in somehow by error. They are small, sometimes stunted mallee type smooth-barked gums. Resistant to termites, they never seem to have hollows in their dead branches and tend to grow mainly on rocky hills or shaley slopes. The second tree should therefore have been the Silver-leafed Box.

I naturally read Trevor Christian's article "A Variable Monitor" (Herpetofauna 14(2) 1981) with interest and found that, probably through my original error, he had got his trees mixed too.

I wonder if an explanation in "Herpetofauna" might be appropriate and would be grateful if you would oblige me in this.

David Stammer,
8 Mentone Avenue,
Cronulla, NSW 2230

OBSERVATIONS OF THE CARPET SNAKE & THE RED-NAPED SNAKE

Michael Maguire, 87 Patrick Street, LAIDLEY QLD. 4341

On the 25th of August, 1980 I received a Red-Naped Snake *(Furina diadema)* which I kept in captivity for five months. Gow (1976) states that this snake feeds mainly on small skinks and presumably, insects. The snake measured 23 centimetres in length and during the 5 months in captivity its food intake consisted of only small skinks, no longer than 4 centimetres in total length. In January 1981 I tried to get the snake to eat the folllowing:-

— flies
— small cockroaches
— small worms

The snake took no interest in this food. So I presume that it rarely eats insects, if any.

In December, 1980 Mr Warren Maguire and I tried to force-feed the snake on a small worm. We got the head of the worm in the snake's mouth, but accidentally broke the worm in half. After removing the worm from the snake's mouth, I returned the snake to its vivarium and I left the two pieces of worm on the nearby table. Half an hour later, the part of the worm that was previously in the snake's mouth showed quite a lot of tissue breakdown compared to the part that wasn't in the snake's mouth. This tissue breakdown was probably caused by injected venom when the worm was in the snake's mouth.

If *Furina diadema* venom can lead to worm tissue breakdown in 30 minutes it is reasonable to expect that it would do a lot of damage in the internal structure of its small lizard prey.

I have in captivity a 2.2 metre carpet python *(Morelia spilotes variegata)*. This snake is healthy and contented and below is a list of the food eaten by the snake from the 11th October, 1980 to the 14th April, 1981.

Date food was consumed	Food eaten
11th October, 1980	one pigeon
19th October, 1980	one baby cavy
11th January, 1981	one pigeon
21st January, 1981	one budgerigar
23rd January, 1981	one budgerigar
25th January, 1981	one budgerigar
26th January, 1981	two budgerigars
2nd February, 1981	one baby cavy
17th February, 1981	one budgerigar
22nd March, 1981	one budgerigar
29th March, 1981	one pigeon
5th April, 1981	one pigeon
14th April, 1981	two adult cavies

On the 19th January, 1980 the carpet python *(Morelia spilotes variegata)* killed and ate a bearded dragon *(Amphibolurus barbatus)* I had in captivity. When the bearded dragon was half swallowed, the snake seemed reluctant to continue but finished the meal anyway, and the lizard was digested within four days. From the start of constriction to when the lizard was completely swallowed took 4 hours.

Acknowledgements

I would like to extend my thanks to Mr Warren Maguire for his assistance and Mr Greg Czechura for encouraging me to publish the notes.

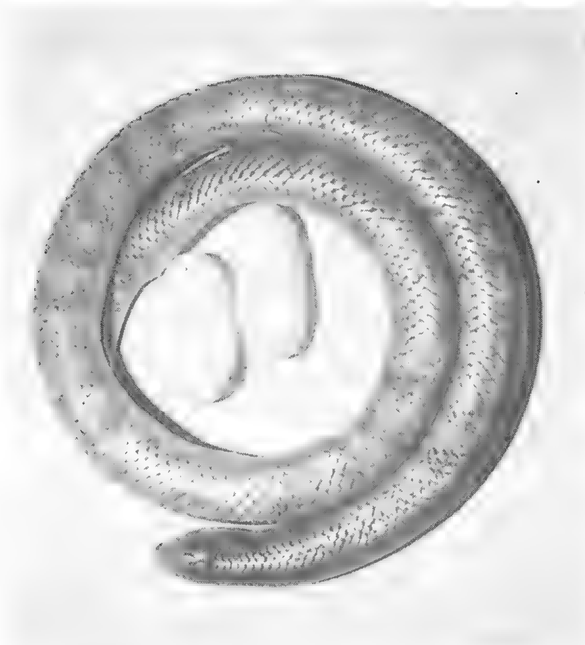


Figure 1 Photograph showing reptilian eggs removed from stomach of *Simoselaps semifasciatus.*

A NOTE ON WATER COLLECTION BY THE BEARDED DRAGON AMPHIBOLURUS VITTICEPS

Mark Fitzgerald, P.O. Box 237, Mullumbimby. NSW. 2482.

A juvenile *A vitticeps* of approximately 20cm total length was kept in an outdoor enclosure exposed to sun but not rain. Water was provided in a shallow container and the lizard was seen to drink from this in the usual manner. On 16th October, 1981 wind drove light rain into the enclosure at 6.30am, and the lizard was found to be collecting water in a method previously unrecorded for this species. The lizard was standing on upright limbs with head and tail below the level of the body. The abdominal part of the body was spread widely and oriented toward the light rain. At the lowest point water was collecting at the tip of the snout and the lizard was licking this. Water could be seen running over the dorsal surface of the head to where it could be collected by the lizards tongue. This posture was maintained for 20-30 minutes during which time the lizard could be seen to periodically lap up the water trickling to its mouth. The body of the lizard was completely wet at this point. The only other Australian lizard recorded obtaining water in a related manner is *Moloch horridus.* In Cogger's "Australian Reptiles in Colour" p. 40 reference is made to the ability of *M. horridus* to absorb water though its skin. Bustard (1970) also refers to this, p. 111.

References

COGGER, H.G. 1967: Australian Reptiles in Colour. Reed.
BUSTARD, ROBERT. 1970: Australian Lizards. Collins.

NOTES ON THE HALF-GIRDLED SNAKE SIMOSELAPS SEMIFASCIATUS (GUNTHER)

Michael Swan 9 Loch st. Kilsyth 3137

From late 1976 to mid 1977, while living in Perth Western Australia I was fortunate enough to observe and photograph many of the local reptiles and amphibians. Perth has an interesting variety of snakes, but none more fascinating than the small, burrowing forms. Many nights were spent searching the roads north of Perth, in an effort to locate and photograph these beautiful snakes.

The bitumen road between Perth and Yanchep (31°33'S 115°41'E.) was favoured as a study area, as the road carried tolerable traffic and passed through a variety of habitats. This road was examined regularly between December 1976 and March 1977. Burrowing snakes were seen most nights, the species recorded being, *Simoselaps semifasciatus, Simoselaps fasciolatus, Simoselaps bertholdi, Neelaps calonotus* and *Neelaps bimaculatus.* No species were ever observed during the day, although Waite states, that *S. bertholdi* "may often be seen basking in the sunshine". By far the most commonly seen species was *Simoselaps semifasciatus.*

Specimens of this latter species were all the same colour, pale red with black bands and an average length of 15cm. Most specimens were collected from sunset to about midnight. No apparent preference to habitat was indicated, though at one point the road is bordered on both sides by pine plantation and reptile activity generally decreased through this section.

Very little information is available on the food item, of this species. Worrell records small skinks as food item, for the related species *bertholdi.* Gow records small skinks as food items for the related species *australis.* Of the numerous specimens recorded dead on road only two were examined for stomach contents. An 18cm. specimen was collected dead on road near Yanchep on the 8th January 1977. It was dissected and two eggs measuring approx. 2.5 cm. were removed from the stomach. The eggs were reptilian and possibly those of the genus *Ctenotus,* or some other similar sized skink. They were discovered deflated and a definite puncture mark was present in each egg. The contents of the eggs had been digested, before the outer leathery casing. It is not totally surprising that these snakes feed upon the eggs of reptiles, as their fossorial habit would bring them into contact with buried eggs. What is surprising is that both eggs were punctured once, so neatly. The eggs were inflated with spirit, through the same neat hole, for closer examination. (see photograph). The specimen is now lodged with the West Australian Museum.

Examination of a second specimen on the 21st January 1977 revealed nothing identifiable in the stomach.

Acknowledgements

For mutual involvement, Stephen Wilson of Perth W.A.

References

COGGER, H.G. (1979): Reptiles and Amphibians of Australia. A.H. & A.W. Reed, Sydney.

GOW, G.F. (1976): Snakes of Australia, Angus and Robertson.

WAITE, Edgar R. (1929): The Reptiles and Amphibians of South Australia, Government Printer.

WORRELL, Eric (1970): Reptiles of Australia, Angus and Robertson.

AN OBSERVATION OF THE RED-BELLIED BLACK SNAKE (PSEUDECHIS PORPHYRIACUS) UTILIZING WATER AS A REFUGE.

Bryan Roberts, (SAHG), 14 Thirza Ave., Mitchell Pk., S.A.5043.

On the 19th October 1981 at 5.10pm., I observed a red-bellied black snake *(Pseudechis porphyriacus)* active on a hillside about 1 km. south of Flinders University, South Australia. Upon detecting me the snake (approx. 1.5m. in total length) fled down the hill and into a nearby creek area. The snake was followed until it took refuge in the small creek. The posterior half of the body was entwined in reeds with the head and other half of the body visible on the creek bed, in about 30cms. of water. The snake remained virtually motionless under the water for 23 minutes (± 10 secs.). I was visible to the snake for this period.

When the snake surfaced it was grasped by the tail and lifted from the water, and I noticed that its movements were considerbaly slower than before. This transformation was no doubt due to the immersion in cold water which would have significantly lowered the snake's body temperature. This cooling effect may also explain why this snake was able to remain submerged for such a prolonged period; a lower metabolic rate requiring less oxygen and producing less carbon dioxide.

CLUTCH AND EGG SIZE IN THE NEW GUINEA CHELID TURTLE EMYDURA SUBGLOBOSA

Jeffrey E. Lovich, Steve W. Gotte, and Carl H. Ernst,
Department of Biology, George Mason University,
Fairfax, Virginia, USA

Little information exists concerning the reproductive biology of the New Guinea red-bellied turtle, *Emydura subglobosa.* The literature only contains the report by Cann (1978) that females lay an average clutch of ten eggs in September.

A 21 cm female from the vicinity of Port Moresby, Papua New Guinea, laid five eggs between 17 and 21 November 1980. On 25 October 1981 seven more eggs were deposited by the turtle in the water of her enclosure. On 3 February 1982 she was palpated and found to be carrying additional shelled eggs. She was then placed in a container with about 15 cm of moist sand, and within hours laid nine eggs. The nest was rather shallow with a depth of five to six cm and a diameter of 20 cm. It is thought that if she had been given access to a sandy area earlier that she would have oviposited sooner. This indicates a potential for double clutching in this turtle which has previously been unreported. The elongated eggs were white and had brittle shells. The 13 measured (several were broken) ranged in length from 31.0-44.0 mm ($\bar{x} = 39.6$) and in width from 19.0-21.3 mm ($\bar{x} = 20.5$).

Additional data on potential clutch size was provided by Dr. George R. Zug for females from the Central District of Papua New Guinea. Two individuals weighing 1280 and 1820 grams contained eleven and nine shelled eggs respectively. A third female weighing 425 grams did not contain shelled eggs. All three were examined 24 November 1971.

Acknowledgements

Our thanks are given to Dr. George R. Zug of the United States National Museum of Natural History for allowing us to use his data.

References:

CANN, J. 1978: Tortoises of Australia. Angus and Robertson, Sydney.

A NOTE ON AESTIVATION IN THE SNAKE-NECKED TURTLE, CHELODINA LONGICOLLIS (SHAW) (TESTUDINES : CHELIDAE).

Bruce C. Chessman, Department of Zoology,
Monash University, Clayton, Vic., 3168.

Present address: Latrobe Valley Water and Sewerage Board,
P.O. Box 348, Traralgon, Vic., 3844.

Aestivation has been reported for various freshwater turtles (Cagle 1944, 1950 ; Mahmoud 1969 ; Degenhardt and Christiansen 1974 ; Ward *et al.* 1976 ; Seidel 1978 ; Wygoda 1979) including the Australian chelid species *Chelodina novaeguineae, C. rugosa, C. steindachneri* and *Pseudemydura Umbrina* (Worrell 1963 ; Cann 1978 ; Burbidge 1981). *Chelodina longicollis* is also capable of such behaviour as the following account indicates.

As part of a study of turtle migration along Chalka Creek (34°43'S, 142°22'E), an intermittent anabranch of the Murray River in the Mallee region of north-western Victoria, I collected a male specimen of *C. longicollis* (822g) by seine netting a drying billabong in December 1972. A small (40g) radio transmitter and a quantity of styrene foam sufficient to counteract its weight were glued to the carapace of the turtle before it was released in the water at the point of capture. Movements of this individual were traced over a period of three months using a Telecon radio transceiver, and the following observations were made.

13 Dec. 1972	Turtle released in billabong.
14 Dec.	Located buried in loose soil and leaf litter, in shade of river red gum *(Eucalyptus camaldulensis(,* approximately 100 m from water ; top of carapace about 1 cm below surface.
24 Dec.	Location as above.
25 Dec.	Location as above.
2 Feb. 1973	Relocated approximately 25 m from previous site, in similar situation.
3 Feb.	Location as above.
4 Feb.	Not in above location; not found.
6 Feb.	Relocated in approximately same spot as previously.
25 Feb.	Location as above.
28 Feb.	Location as above.
4 Mar.	Location as above.
24 Apr.	Not at above location ; not relocated.

Searching of adjacent areas revealed a second turtle in a similar aestivating refuge, covered in decomposing leaf litter and wedged in the fork of a fallen limb. Such locations combined several suitable microhabitat features. The humified earth beneath river red gums was the only soft, moist soil to be found in the vicinity under the arid summer conditions of the study, other soils generally consisting of dry sand or compacted clay. The sites selected also offered ready access to nearby billabongs, and were inundated at times of flooding of the Murray River.

Other types of refuges may also be used by aestivating *C. longicollis.* Workmen excavating a section of Chalka Creek during September 1972 reported finding a live specimen buried in about 50 cm of soil in the bottom of a dry billabong. It seems probable, however, that locations such as those occupied by the transmitter-equipped turtle are more frequently used.

Acknowledgements

This work formed part of a Ph. D. research programme at Monash University and was supervised by Professor J.W. Warren. I am also grateful to Mr J. Hansen for design and construction of the radio transmitter, and to the Victorian Fisheries and Wildlife Division for collecting permits.

Literature Cited
BURBIDGE, A.A. (1981): The ecology of the western swamp tortoise *Pseudemydura umbrina* (Testudines : Chelidae). *Aust. Wildl. Res.* 8 : 203-223.
CAGLE, F.R. (1944): Home range, homing behaviour, and migration in turtles. *Misc. Publs. Mus. Zool. Univ. Mich.* 61 : 1-34.
——— (1950): The life history of the slider turtle, *Pseudemys scripta trootsii* (Holbrook). *Ecol. Monogr.* 20 : 31-54.
CANN, J. (1978): Tortoises of Australia. Angus and Robertson : Sydney.
DEGENHARDT, W.G. and J.L. CHRISTIANSEN (1974): Distribution and habitats of turtles in New Mexico. *Southwest Nat.* 19 : 21-46.
MAHMOUD, I.Y. (1969): Comparative ecology of the kinosternid turtles of Oklahoma. *Southwest Nat.* 14 : 31-66.
SEIDEL, M.E. (1978): Terrestrial dormancy in the turtle *Kinosternon flavescens* : respiratory metabolism and dehydration. *Comp. Biochem. Physiol.* 61A : 1-4.
WARD, F.P., C.J. HOHMANN, J.F. ULRICH and S.E. HILL (1976): Seasonal microhabitat selections of spotted turtles *(Clemmys guttata)* in Maryland elucidated by radioisotope tracking. Herpetologica 32 : 60-64.
WORRELL, E. (1963): *Reptiles of Australia,* 1st edition. Angus and Robertson : Sydney.
WYGODA, M.L. (1979): Terrestrial activity of striped mud turtles, *Kinosternon baurii* (Reptilia, Testudines, Kinosternidae) in west-central Florida. *J. Herpetol.* 13 : 469-480.

SEASONAL COLOUR CHANGES IN THE INLAND TAIPAN OXYURANUS MICROLEPIDOTUS (McCOY).

P.J. Mirtschin, 18 Creber Street, Whyalla Playford, South Australia 5600.

Colour changes have been recorded in a number of lizards. Worrell (1963) notes colour changes in some agamids and my own experiences with *Amphibolurus vitticeps* and *Amphibolurus cristatus* reflect that they undergo rapid colour changes apparently due to changes in temperament. Observations made at the Whyalla Fauna Park with Western Brown Snakes *Pseudonaja nuchalis* and Taipans *Oxyuranus scutellatus scutellatus* support those made by Banks (1981). Information is provided here on the colour changes that occurred with four specimens of the Inland Taipan *Oxyuranus microlepidotus* kept at Whyalla.

Three male *O. microlepidotus* were collected April 1980 from Goyders lagoon and were recorded by Mirtschin (1981). Two female *O. microlepidotus* were collected March 1981 also from Goyders lagoon. Two males and both females were retained at the Whyalla Fauna Park for further study. All specimens ranged in length from 135 cm to 176 cm.

When the two males were caught, one was dark in dorsal colouration ranging from black on the head to dark mustard to brown on the body. The other male was dark olive brown on the head and a lighter mustard on the body. Both exhibited banding as described by Covacevich etal (1981).

The males became darker during winter and then lighter towards summer. This became more noticeable after sloughing. By mid summer the lighter coloured male had changed to a golden straw colour with no darker colouration on the head. Banding was retained. The colour change in the darker male was less dramatic and by mid summer it was slightly lighter in colour and retained the black head. During the following year, similar colour changes were experienced by the two males.

The two females were both uniformly dark brown when caught, exhibiting banding as described by Covacevich etal (1981). Towards mid 1981 they changed to darker colours and, as with the males, lightened in colour as summer approached. One of the females adopted an almost identical colouration to that of

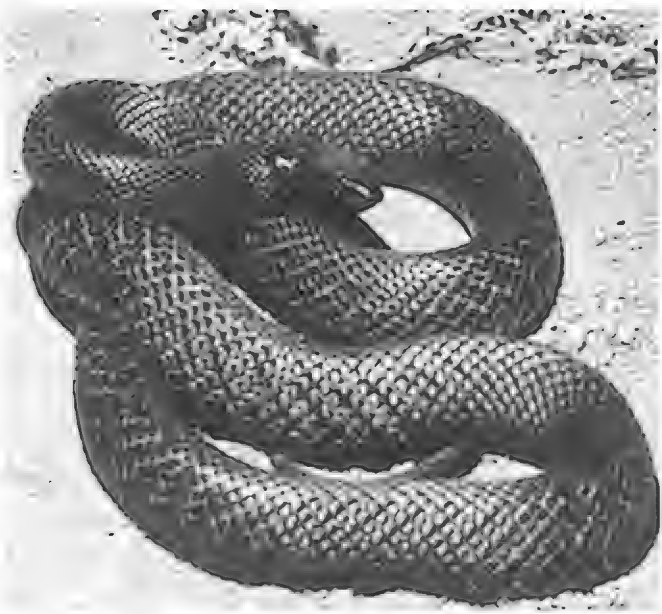


Figure 1 A female *O. microlepidotus* showing melanism during winter.

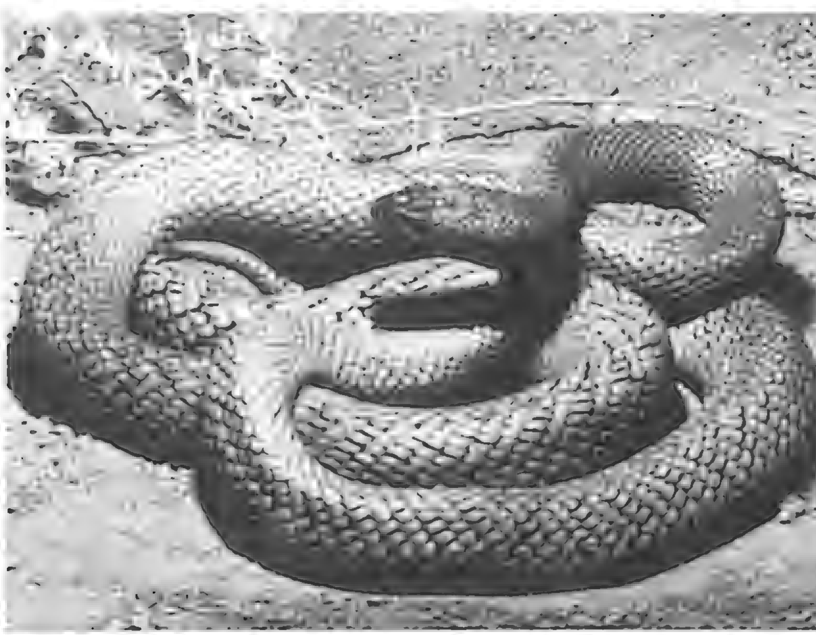


Figure 2 The same female as shown in figure 1 showing a pale form during summer.

the lighter coloured male, again without the darker head. Both females darkened in colour as the winter of 1982 approached.

B. Searle (pers comm.) has noted similar seasonal colour changes with a captive female *O. microlepidotus* kept at Warrnambool Victoria.

Observations by Mr F. Wilson of Clifton Hills Station in the far northeast of South Australia suggest that the Inland Taipan is active for all months of the year except July. Data from the South Australian Year Book 1981 gives the average monthly maximum temperatures in the range of the Inland Taipan as 18 - 23 °C in July to 36 - 39 °C in January. It could be suggested, as for *P. nuchalis* (Banks 1981), that the species uses the darker colour in the cooler months to optimise radiation absorption. Alternatively lighter colours in summer minimise radiation absorption and would allow longer ground surface activity times.

References

BANKS, C. (1981): Notes on Seasonal Colour Changes in a Western Brown Snake. Herpetofauna 13 (1).

COVACEVICH, J., S.B. McDOWELL, C. TANNER and G.A. MENGDEN (1981): The relationship of the Taipan, *Oxyuranus scutellatus,* and the small-scaled Snake, *Oxyuranus microlepidotus* (Serpentes : Elapidae). Proc Melb. Herp. Symp. May 1980.

MIRTSCHIN, P.J. (1981): South Australian Records of the Inland Taipan. (Oxyuranus microlepidotus McCoy 1879) Herpetofauna 13 (1).

WORRELL, E. (1963): Reptiles of Australia. Angus & Robertson. Sydney.

A DEFENSIVE REACTION OF GONOCEPHALUS SPINIPES (DUMERIL)

John Bevan, 4 Bruce Street, Strathmore 3041

While at Coffs Harbour in January 1982 I had the good fortune to collect an adult *Gonocephalus spinipes.* The lizard was caught 25 metres from the junction of Park Creek and Swanns Road, which is surrounded by rainforest in the Bruxner Park Flora Reserve.

The morning was overcast and light rain had been falling. When caught at 12.30 pm on a trunk of a small tree it was approximately 1½ metres from the ground. When seen, the lizard relied on camouflage and made no attempt to escape. Once caught it became most aggressive attempting to bite at every opportunity.

During a most frustrating photographic session, unusual behaviour was observed. When the lens of the camera was moved close to the lizard it slid around to the opposite side of the branch without appearing to move its legs. It was thought that the lizard was just afraid of the lens however when released at the point of capture it was seen to repeat this behaviour.

Once released the lizard quickly moved up the tree to approximately 5 metres from the ground. I returned to the tree from different directions throughout the afternoon and, when I was metres from the tree the lizard was seen to move slowly to the opposite side of the trunk making it impossible to see.

There seems to be little information published regarding the defensive reactions of lizards. It is known that some Agamids crouch when approached, other lizards use threatening displays. Bustard (1970, p107) states that he came across a specimen of *G. spinipes* which made no attempt to run away and relied on its camouflage to avoid detection.

Unfortunately I have not had the opportunity to observe this behaviour in any other *Gonocephalus;* however it is quite probable that this is a common trait of the genus. With this cryptic behaviour, and with its camouflage, it is understandable why the lizard is so difficult to locate.

References

BUSTARD, R. (1970): Australian Lizards. Collins.

COGGER, H.G. (1979): Reptiles and Amphibians of Australia. Reed.

PETER RANKIN TRUST FUND FOR HERPETOLOGY
CALL FOR APPLICATIONS

Applications are now being called for the third round of grants-in-aid to be awarded by the Peter Rankin Trust Fund for Herpetology. Individual grants will be in the range $50.00 — $500.00. *The closing date for applications is normally the 10th June in each year, but applications are invited at anytime.*

Applicants must be under 30 years of age, be permanent residents in/of Australia and must not already hold a position as a professional biologist. Applications are sought from all Australian States.

They should include the following information:-

1. *Applicant's name, age and permanent address.*
2. *A brief outline of the project.*
3. *A brief budget specifying*
   a). Travel and field costs; b). equipment and c). miscellaneous (with brief explanation).
4. *Proposed date of completion.*
5. *The names of two people to whom the Selection Committee may refer if necessary.*

Applications to:

The Peter Rankin Trust Fund for Herpetology.
The Australian Museum,
P.O. Box A 285,
SYDNEY SOUTH. N.S.W. 2000.

In accepting an award successful applicants will thereby agree to the following:

1. *To comply with all State and Commonwealth fauna regulations.*
2. *To submit a brief report within one month of the completion date.*
3. *To acknowledge the Peter Rankin Trust Fund for Herpetology in any publication.*

The Peter Rankin Trust for Herpetology is an Australia-wide fund which seeks to provide small grants-in-aid to young Australian Herpetologists. The Fund makes awards annually to a total of approximately $1000.00. Contributions to the invested capital of the Fund are continually being sought by the Committee overseeing the Fund. The members of this Committee are Dr. Harold G. Cogger, Dr. Allen E. Greer and Mr. Aubrey N. Rankin.

It may be of interest to readers to learn of the grants which have been made from this fund in the two years of its operation:

Glen Shea (Sydney, N.S.W.), for morphological studies in the genera *Trachydosaurus* and *Tiliqua. $500*

Arthur Georges (Brisbane, Qld), for a study of the growth of the freshwater tortoise *Emydura krefftii* on Fraser Island. $220

Mark Fitzgerald (Mullumbimby, N.S.W.), for a study on the ecological impact on the Yellow-faced Whip Snake *(Demansia psammophis)* and Marsh Snake *(Hemiaspis signata)* of parasitism by the nematode *(Ophidascaris pyrohus). $200*

Russell Parker (Rockhampton, Qld.), for a survey of the *Chelonia depressa* rookery on Peak Island, Queensland. $160

Glen Burns (Armidale, N.S.W.), for studies on the reproductive biology and population ecology of sea snakes. $480

Steven Delean and *Chris Harvey* (Seaview Downs, S.A.), for studies of the biology of geckos of the genus *Nephrurus* in South Australia. $426

NOTES TO CONTRIBUTORS

"Herpetofauna" publishes original articles on any aspect of reptiles and amphibians. Articles are invited from any interested author; encouragement is given to articles reporting field work and observations.

1. PUBLICATION POLICY
Authors are responsible for the accuracy of the data presented in any submitted article. Current and formally recognised taxonomic combinations should be used unless the article is itself of a taxonomic nature proposing new combinations or describing new species. Upon publication, copyright in the article (including illustrations) become the property of the Affiliation. The original illustrations will be returned to the author, if requested, after publication.

2. SUBMISSION OF MANUSCRIPT
One copy of the article (including any illustrations) should be submitted, the author retaining a second copy. All material should be typewritten or clearly hand-written and double spaced. Grammar and punctuation should be checked and all pages must be numbered consecutively. The metric system should be also used throughout. All scientific names and subheadings should be underlined. The author's name and address should appear under the title. Latitude and longitude of the localities mentioned should be indicated.

3. ILLUSTRATIONS
Illustrations (drawings, maps or photographs) should be twice the anticipated published size if possible. Drawings should be in Indian Ink on high quality, matt white paper. Author's should retain a copy of each illustration.

4. REFERENCES
Any references made to other published material must be cited in the text, giving the author, the year of publication and the page numbers if necessary, e.g. Jones: (1968, p.24). At the end of the article full reference should be given. (See this journal).

5. PROOFS
If any changes, other than minor ones, need to be made to the article, a proof with suggested changes will be sent to the author for his revision. Proofs should then be re-submitted by the author as soon as possible.

6. REPRINTS
Free reprints for authors are beyond the financial resources of the Affiliation. Authors of articles who are members of an affiliated society will receive their copy in the normal way. Other authors will have posted to them one copy of the issue Herpetofauna in which their article appears. Additional copies of Herpetofauna can be purchased from the Editor by authors for A$1.00 per copy. Contributors may reproduce copies of their papers or notes for private circulation.

CONTENTS

ISSN 0725-1424

Printed by:
Wentforth Print, 35 Great North Road, Auckland, 2. P.O. Box 68-133